Water Plant Optimization Study

GRIMSBY WATER TREATMENT PLANT

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WATER PLANT OPTIMIZATION STUDY

Grimsby
Water Treatment Plant

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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of the Environment.

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

1.0 INTRODUCTION

This report on the Grimsby Water Treatment Plant Optimization Study was prepared by MacLaren Engineers Inc. on behalf of the Ontario Ministry of the Environment under Agreement dated April 24, 1987.

The project is a result of the Drinking Water Surveillance Program (DWSP) being carried out by the Ministry of the Environment on municipal water supplies. Under this program, which began on April 1, 1986, a continuously updated base of information is being established on Ontario water plants and water quality. The Water Plant Optimization Study (WPOS) program was initiated for each plant entering the program in order to complement the data gathered from the Drinking Water Surveillance Program.

The study approach and detailed Terms of Reference for the Water plant Optimization Study were prepared by the Ministry of the Environment. The purpose of the study is to document and review present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

To maintain a current database of information, it is envisaged that the WPOS report will be updated on an annual basis.

As a supplement to the Water Plant Optimization Study for the Grimsby Water Treatment Plant, a separate report was prepared on the existing waste management practices at the plant. The report includes recommendations for the optimization handling and disposal of wastes generated at the plant and provides first-order cost estimates for the recommended option. The report was prepared by MacLaren Engineers Inc. for the Ministry of the Environment under the title: Wastewater Disposal Study, Grimsby Water Treatment Plant, August, 1988.

2.0 HIGHLIGHTS OF STUDY

2.1 Raw Water Quality

The raw water source for the Grimsby plant is Lake Ontario. Water is drawn from a depth of 3 to 4 m through the main gravity flow intake which extends about 230 m into the lake. A submersible pump, installed in about 2 m of water at the end of an existing pier about 50 m offshore, serves to supply additional water to the plant during the summer period.

Raw water is subject to wide variations in turbidity and bacteriological quality. The water quality at the main intake is influenced by runoff from the nearby Forty Mile Creek and the re-suspension of lake bottom sediments during storm events. Similarly, the water quality at the pier intake is influenced by the turbulence in the lake.

Monthly average raw water turbidities at the main intake for 1984 to 1986 varied from 1.7 to 35.8 NTU; whereas daily average values varied from 0.8 to 144.8 NTU. The pH of the raw water varied from 7.9 to 8.6 units and was found to be at its highest during the algae growing season. Although no data for algae content were available, test results for chlorophyll a revealed that algae are present in the raw water at low to moderate levels.

2.2 Flow Measurement

Flow is measured for the following process streams:

- raw water from the pier pump to the pressure filter - by orifice plate flow meter;

- treated plant output water - by venturi flow meter;

- backwash water used in cleaning of the pressure filters - by orifice plate flow meter.

The raw water flow from the low lift pumps is not metered.

Orifice plate flow meters are equipped with flow totalizers and the venturi meter includes low and high flow differential pressure transmitters, totalizer and circular chart recorder.

2.3 Plant Capacity and Process Design

The Grimsby W.T.P. has two treatment trains consisting of a conventional gravity flow filtration section and a pressure filtration section.

The rated capacity of the gravity filtration plant is 13,600 m^3/d.

The plant includes chemical coagulation, two-stage flocculation, sedimentation and dual media filtration.

The pressure filter plant comprises chemical coagulation and single medium sand filters. The pressure filters have a rated capacity of 5,700 m^3/d, and are only operated during the summer during periods of peak demand, since the pier pump intake is not frost protected.

Alum was used as the coagulant in 1984 and 1985, while polyaluminum chloride was used in 1986. Gaseous chlorine, applied in solution form in pre- and postchlorination modes, is used for disinfection. Taste and odour control is achieved by the addition of powdered activated carbon, as necessary.

Sedimentation tank sludges and filter backwash water are discharged directly to the lake through individual drain pipes.

Capacity limitations exist in both sections of the plant. Pressure filters operate on the principle of direct filtration. This process is affected by raw water quality, and when the raw water turbidity exceeds about 15 NTU the rated capacity of 5,700 m^3/d cannot be sustained on a continuous basis. In the gravity filtration plant, the pretreatment

units are severely overloaded at the rated capacity of 13,600 m^3/d resulting in poor performance of the sedimentation units. Also, since there are only two gravity flow filters, it is necessary to reduce raw water flow with one filter out of service in order to prevent overloading of the in-service filter.

During the winter the plant intake is subject to partial blockage by frazil ice which greatly affects plant capacity. At times, during very cold winter nights, ice blockage has been so severe that several backflushes were required resulting in the depletion of the stored water in the distribution system.

2.4 Process Automation

No process automation equipment has been provided at the Grimsby W.T.P. Pumps and all motorized equipment are started and stopped manually. Chemical feed pumps operate at preset constant speed and constant stroke and require manual adjustment for quantitative control of the dosage with varying flow. Only the chlorinators are equipped with flow proportional controllers.

The discharge from the gravity flow filters is controlled by a self-powered mechanical rate control valve.

2.5 Plant Operations

The plant operating staff consists of one senior plant operator and three plant operators. The area superintendent of the Region of Niagara is responsible for the treatment process and all activities at the plant. Plant maintenance is the responsibility of the Region's area foreman.

Plant operators are responsible for the day-to-day running of the plant, which is staffed on the basis of two 12-hour shifts per day seven days per week.

2.6 Process and Quality Control

The operator on duty maintains the daily log sheet and, at various

chemical treatment, and the results of quality control tests comprising raw and treated water turbidity, odour, temperature, and chlorine residual analyses. Jar tests are occasionally performed using a Phipps and Bird stirring apparatus to determine the optimum coagulant dosage. Routinely though, the coagulant dosage is selected on the basis of experience and past trends.

3.0 PLANT PERFORMANCE

3.1 Particulate Removal

In general, the treatment process performed well at the hydraulic loadings and solids levels experienced during the study period. On a monthly average basis, filtered water effluent turbidities ranged from 0.10 to 0.56 NTU regardless of which coagulant was used, alum or polyaluminum chloride. On a daily basis, higher turbidity values, in excess of 1.0 NTU, were experienced on several occasions as a result of rapidly fluctating levels of raw water turbidities. Poor effluent quality was normally contained to one day except for the period of December 27 to 29, 1986, when the effluent turbidity was consistently above 1.0 NTU.

3.2 Disinfection

Disinfection of the raw water is achieved by prechlorination and postchlorination. A good record was established for 1984 to 1986; none of the test samples contained fecal coliform organisms and only one sample in 1986 and two in 1985 tested positive for total coliform.

3.3 Taste and Odour

Unpleasant taste and odours are encountered during the summer months, and on occasions during other times of the year. These odours are effectively controlled by powdered activated carbon treatment.

3.4 Fluoridation

No fluoride treatment is in effect at the Grimsby W.T.P. for the control of dental caries.

3.5 Aluminum in Treated Water

Neither the raw nor treated water is analyzed for aluminum outside of the recently implemented DWSP by the MOE.

In view of the significance of aluminum residuals in the treated water, it is suggested that at least weekly tests be carried out to obtain this information.

3.6 Stability of Water

On the basis of the Langelier Saturation Index, it was determined that the treated water is slightly aggressive during the winter.

4.0 RECOMMENDATIONS

4.1 Physical Improvements

1. Install a Streaming Current Detector (S.C.D.) to monitor the optimum coagulant dosage as determined in the laboratory by jar tests and/or streaming current titrations.

2. Following first-hand experience gained with the operation and performance of a S.C.D., a decision can be reached as to whether automatic dosage control based on a 4 to 20 mA DC output signal from the S.C.D. is warranted. The implementation of this recommendation would require the provision of new chemical feed pumps with automatic speed and stroke adjustment capabilities.

3. The application of coagulant at the Grimsby W.T.P. is inadequate; although the change made in 1987 is an improvement over the original feed point for the main raw water supply. Optimization of the coagulation process, and for the most efficient use of the coagulant chem;ical, it is necessary to flash mix the chemical with the raw water at a fraction of a second. This high intensity mixing can best be achieved at the Grimsby plant by installing chemical injector nozzles, one in the 400 mm dia. common discharge header from the low lift pumps and one in the 200 mm dia. raw water header supplying the pressure filters.

4. Operate the existing flocculators at higher speed in order to increase the efficiency of floc formation and to maximize utilization of the chemical coagulant.

5. The problem with frazil ice formation at the bell mouth of the main intake can be partially overcome by installing a compressed air system consisting of:

   - 1 - 85 m^3/h capacity air blower, 3 kW motor

   - 2 - 75 mm diameter air line with perforated ring header around bell mouth of intake.

6. Continue using powdered activated carbon for the control of taste odour.

4.2 Studies

1. The optimum coagulant dosage, which is currently selected on the basis of extensive jar tests and the plant's track record, should be documented including methods of evaluation procedures and actions taken and results, in order to establish a predictive tool. Jar tests results could be plotted (coagulant dosage versus raw water turbidity), in the form of a dosage chart for use by the operators. With time, the chart can be adjusted to reflect the experience of full-scale treatment.

2. In an effort to improve the performance of the sedimentation and filtration processes at the Grimsby plant, many tests have been carried out by representatives of chemical suppliers that market coagulation polymers and polymer preconditioned primary coagulants (i.e. HyperI+on™ by General Chemical Canada Ltd.). Unfortunately, none of the tests with the exception of PACl, proved sufficiently successful to warrant further consideration. For this reason it is recommended that the pretreatment process and unit operations at the Grimsby plant be reviewed in detail by a consulting engineer. Such a study should include a second assess-

ment of the use of flocculant aid polymers and other commercially prepared primary coagulants. In addition, an in-depth assessment should be made of existing and required mixing facilities.

In Section E of this report it has been concluded that the use of a cationic polymer flocculant aid would be beneficial and result in improved performance of the treatment process. The investigation recommended herein should confirm whether or not polymer storage and feed equipment for the application of a cationic or non-ionic polymer as a flocculant aid should be installed at Grimsby W.T.P.

3. Studies should be carried out to determine the feasibility of operating pressure filters during the winter. Two supply points should be investigated, 1) from the effluent section of the sedimentation tanks, and 2) from the plant's main raw water wet well.

4. Effluent turbidity from pressure filters should be monitored on a routine basis.

5. Continue to let a filter rest for about 15 minutes after a wash before returning the filter to service, whenever possible.

6. Continue to minimize hydraulic surges during start up by slowly opening the filter effluent valve.

7. Investigate filtering to drain via the filter drain valve (at low rate) for 15 to 20 minutes as an alternate means of improving filter effluent quality at start-up.

8. The efficiency of chlorination in the postchlorination mode can be improved by increasing the available contact time. This could be achieved by chlorinating individual filter effluents from both the gravity flow filters and the pressure filters. Also, considerations should be given to slightly increasing the post-chlorine dosage.

In light of the Region's current expansion and development plans regarding the Grimsby water supply, the concept for increasing the chlorine contact time will need to be considered further. It is therefore recommended that a study be undertaken to establish the feasibility and costs of this proposal.

9. The overall efficiency of the chlorination process can be improved by lowering the high raw water pH.

   The feasibility of incorporating pH adjustment treatment at the Grimsby plant should be investigated.

10. Raw and treated water should be analyzed periodically for aluminum content. Also, tests should be carried out to establish the levels of total trihalemethanes in the treated water. Since both of these parameters are now being monitored by DWSP, the data should be examined and the future test frequency determined.

4.3 Long-Term Modifications

1. In order to monitor and record raw water flows, and to permit quantitative pacing of chemicals, a raw water flow meter should be installed on the 400 mm diameter discharge pipe from the low lift pumps. This meter could be of the ultrasonic, time transient type, and should be equipped with a flow indicating controller, totalizer, signal transmitter and flow recorder.

2. In order to improve cold weather operations of the flocculation and sedimentation basins, existing tankage should be covered and weather-proofed. Options to be considered are conditional upon the Region's future development plans and include:

   Option 1

   Install a low height roof using precast, prestressed, hollow-core slabs, or single or double tees.

Option 2

Enclose the entire tankage in a building equipped with all necessary services. Enclosing of the process units would allow for the future installation of mechanical equipment in floc and sedimentation tanks thereby increasing the performance and capacity of these units.

3. Considerations should be given to the construction of a new and larger intake, properly sited in deep water where the raw water quality is better and more consistent compared with that of the present location.

   The existing low lift pumping station also is inadequate in the long-term and will require to be upgraded and expanded.

   The above recommendations are conditional upon the Region's future expansion and development plans for meeting future water needs of the service area.

4. In order to meet the increasing water demand of an expanding service area, and in view of the problems associated with a possible expansion of the existing plant, we endorse the Region's current plans for the construction of new water treatment plant on a new site centrally located within the future service arca.

ACKNOWLEDGEMENTS

Members of the Project Committee for the Grimsby Water Treatment Plant are listed on the fly-sheet of this report. The cordial assistance provided by each of these members during the course of this study is hereby gratefully acknowledged. To all others who have assisted us in any way, we express our sincere thanks.

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SYMBOLS AND ABBREVIATIONS

Symbols Used

d	day
h	hour
min.	minute
s	second
m	metre
mm	millimetre
cm	centimetre
m^2	square metre
m^3	cubic metre
L	litre
mL	millilitre
kg	kilogram
mg	milligram
µg/L	microgram per litre
L/h	litre per hour
L/min.	litre per minute
L/s	litre per second
m/s	metre per second
m/h	metre per hour (filtre rate or surface overflow rate equal to $m^3/h.m^2$)
m^3/d	cubic metre per day
kg/h	kilogram per hour
°C	degree Celcius
FTU	Formazin turbidity unit
NTU	nephelometric turbidity unit
ACU	apparent colour unit
TCU	true colour unit
A.S.U. per mL	areal standard units per millilitre
s^{-1}	mean velocity gradient, metre per second per metre
rpm	revolution per minute
V	volt
A	ampere
kVA	kilovolt ampere
kW	kilowatt
>	greater than
<	less than
%	per cent

Abbreviations Used

DWSP	Drinking Water Surveillance Program
MOE	Ontario Ministry of the Environment
WPOS	Water Plant Optimization Study
Al	aluminum
$CaCO_3$	calcium carbonate
Cl_2	chlorine
E.S.	effective grain size
U.C.	uniformity coefficient
L.I.	Langelier Saturation Index
MF	membrane filter technique for enumerating bacteria in water
pH	expresses the intensity of the acid or alkaline condition of a solution
SWD	side water depth
THM	trihalomethane
TTHM	total trihalomethane

INTRODUCTION

AND

TERMS OF REFERENCE

INTRODUCTION AND TERMS OF REFERENCE

1. BACKGROUND

The Ontario Ministry of the Environment has instituted a Drinking Water Surveillance Program. The Program began on April 1, 1986 and encompasses all municipal water supplies in Ontario. The primary objectives of the DWSP for Ontario are to establish a reliable database on water quality which will encompass a wide range of parameters, including pesticides and organic compounds, and to maintain information current by continuously updating the database. In connection with the DWSP, a plant investigation and process evaluation study is initiated for each plant entering the program. A major goal of the study is to document information on the plant's process design and operations, and to determine an optimum treatment strategy for contaminant removal at the plant. It is intended to update the study on an annual basis in order to maintain the database current. The information from these studies will allow valid water quality data to be collected. The results will further identify potential problem areas, serve as the basis for remedial action, and provide a framework for defining contaminant levels and trends.

2. TERMS OF REFERENCE

A detailed protocol for the Water Plant Optimization Study has been prepared by the Ministry for use by the consultants engaged for the optimization studies. This study of the Grimsby Water Treatment Plant has been conducted in accordance with the protocol. The main objective of the plant investigation and process evaluation study is:

> *"To review the present conditions and determine an optimum strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes."*

To meet this objective, Terms of Reference were prepared by the Ministry (and later re-issued as Rev. 1 on 06/04/87) consisting of eight specific work tasks which require the consultant to examine, in

detail three years of daily and monthly operating data, to prepare a comprehensive assessment of plant operations and the level of performance achieved, and to provide recommendations for short and long term modifications in order to obtain optimum disinfection and contaminant removal. The complete revised Terms of Reference are included at the end of this report as Appendix D.

As a supplement to the Water Plant Optimization Study, the consultant was commissioned to prepare a separate report on the handling and disposal of wastewaters generated at the plant.

3. GRIMSBY WATER SYSTEM

The Grimsby Water Treatment Plant is operated by the Regional Municipality of Niagara to supply drinking water to the Town of Grimsby. The total population of the service area in 1986 was about 14,665.

The main plant design is based on the conventional treatment process for particulate removal comprising pipe flow blending of coagulant, flocculation, sedimentation and gravity filtration. Seasonally operated pressure filters normally are run in the direct filtration mode. Chemical treatment processes consist of coagulation, disinfection and control of taste and odour.

The capacity of the Grimsby water supply is inadequate to meet the increasing water demand by the expanding service area. A plant expansion has been considered but was found not to be feasible in view of the conditions of the existing facilities, some of which date back to the original installation of the water supply, and the inadequate capacity of the intake. For this season, the Region of Niagara is planning to provide an alternate source of supply or to build a new treatment plant located on a new site within the next five years.

SECTION A

RAW WATER SOURCE

SECTION A - RAW WATER SOURCE

A.1 SOURCE

The Grimsby Water Treatment Plant is located on the shoreline of Lake Ontario in the Town of Grimsby. Water is drawn from the lake via two intakes:

i) a gravity intake - 450 mm dia. cast iron and steel pipe sections, about 230 m long, with bell mouth concrete intake crib located in about 3 to 4 m of water (this is the plant's main intake);

ii) a submersible pump at end of the pier (pier pump) discharges via forcemain laid on top of pier to pressure filters in the Pumphouse. The pier pump is located 50 m off-shore in about 2 m of water and is used during the summer months only.

A.2 QUALITY

Lake Ontario water in the region of the Grimsby Water Treatment Plant main intake is subject to wide variations in turbidity and is generally high in organic pollution as measured by the coliform group of indicator organisms. The water quality is strongly influenced by runoff from the nearby Forty Mile Creek and reflects the lower water quality typically found in near-shore waters of the lake. In addition, the water quality at both intakes may be influenced by wastewater discharges to the lake west of the intakes consisting of:

i) pressure filter backwash water;

ii) gravity filter backwash water;

iii) sedimentation tank sludge;

iv) wet weather high level overflows from the sewage pumping station located in the park next to the sedimentation tanks.

Raw water analyses are performed at the Ministry of the Environment laboratories and at the plant for physical and chemical parameters. Test results for 1984 to 1986 are presented in the protocol tables for the Optimization Study attached as Appendix C to this report. A summary of the data for several parameters is presented in Table A.1 to express general water quality conditions. A more detailed discussion of various water quality parameters follows.

a) Physical Parameters

Turbidity: The average monthly turbidity varied from a low of about 1.7 NTU to a high of about 35.8 NTU. Greater fluctuations occurred in daily values which varied from 0.8 NTU to 144.8 NTU. The overall monthly average for the three-year record was 11.9 NTU. The higher values of turbidity generally occurred during the winter, spring and fall periods of the year.

Colour: Colour is a measure of the clarity of the water. At the Grimsby intake, the apparent lake water colour is influenced significantly by the colour contributed by suspended matter. The data record indicates that apparent raw water colour varied from 1.5 to 45 ACU, and that the monthly average was 8.3 ACU.

Temperature: Raw water temperature is recorded daily at the plant by reading a thermometer located on the low lift discharge pipe. Average monthly temperatures were less than 9°C except for July through September when the average temperature was 15.8°C. During the year, daily extreme values of 0°C to 22.5°C have been observed.

Taste and Odour: The raw water odour level is checked informally several times during the day by the operator. The operator reported that odour problems can arise at any time of the year.

b) Chemical Parameters

pH Value: The average monthly raw water pH generally was above 8.0 units and ranged from 7.9 to 8.6 units. The highest levels occurred during the algae growing season.

Alkalinity: Total raw water alkalinity during 1984 to 1986 varied from 92.2 to 144.4 mg/L as $CaCO_3$. The monthly average alkalinity value for the study period was 99.4 mg/L.

Hardness: The monthly average raw water hardness was established as 133.3 mg/L as $CaCO_3$. Little variation was observed in this value which ranged from 121 to 148 mg/L. At this level of hardness the water may be classified as being moderately hard.

c) Microbiological Parameters

(i) Bacteriological Water Quality

The record for bacterial raw water quality indicates that the level of total coliform organisms varied widely from 5 to 8,800 counts/100 mL and that the monthly average was 708 counts/100 mL. The overall bacterial population, as measured by the total coliform background test, was considerably higher and had a monthly average for the three years of 22,455 counts/100 mL. Fecal coliform organisms were present in each test and varied from 2 to 1,507 counts/100 mL; the monthly average was 64 counts/100 mL. These results indicate that the source water was polluted and that contamination was of fecal origin.

(ii) Nuisance Organisms (Algae)

No algae counting data were available for the Grimsby plant. During 1984 and 1985 three to five raw water samples per month were analysed at the Ministry of Environment laboratory for chlorophyll a, and chlorophyll b content. Test results for chlorophyll a which is an indicator of the algae biomass, indicate average monthly values of 1.7 to 36.3 µg/L and a two-year average of 5.4 µg/L. For chlorophyll b the monthly average range was 0.3 to 3.2 µg/L and the two-year average was 1.4 µg/L. Individual test results for chlorophyll a varied from 0.5 to 134.0 µg/L. A concentration of 20 µg/L and above is representative of a moderate level of algae.

TABLE A.1

LAKE ONTARIO RAW WATER QUALITY CHARACTERISTICS
AT THE GRIMSBY WATER TREAMENT PLANT

	3-Year Summary, 1984 to 1986	
	Range (Monthly Average)	Average
Turbidity, FTU	1.7 - 35.8	11.9
Colour, ACU	1.5 - 45	8.3
pH, Units	7.9 - 8.6	8.26
Temperature, °C	0 - 22.5	7.7
Alkalinity as $CaCO_3$, mg/L	92.2 - 144.4	99.4
Hardness as $CaCO_3$, mg/L	121 - 148	133.3
Total Coliform, (MF) per 100 mL	5 - 8,800	708
Total Coliform Background, (MF) per 100 mL	136 - 125,380	22,455
Fecal Coliform, (MF) per 100 mL	2 - 1,507	64
Chlorophyll-a, µg/l	1.7 - 36.3	5.4
Chlorophyll-b, µg/L	0.3 - 3.2	1.4

SECTION B

FLOW MEASUREMENT

SECTION B - FLOW MEASUREMENT

B.1 METHOD OF MEASURING FLOWS

Raw Water

Raw water is supplied to the plant from two locations. The majority of flow is conveyed to the treatment facilities via the 400 mm diameter discharge header from the low lift pumps. During periods of peak demand in the summer months, the raw water flow can be increased with the use of a portable submersible pump located at the end of a pier extending into the lake (pier pump). The submersible pump discharges raw water to the plant via a 200 mm pipe laid partially above ground.

Both the low lift pumps and the pier pump can discharge either to the pressure filters or to the gravity sedimentation and filtration plant. However, the two discharge headers are not directly connected and no metering facilities are provided to measure flow from the low lift pumps. A single orifice type water meter is located on a run of pipe which carries water flow from the pier pump and/or the settling tanks to the pressure filters. Since the low lift discharge header bypasses this meter, no record of total raw water pumpage is available. Flow recorded by this meter was not incorporated into this report, since it does not relate to total raw water pumpage.

Treated Water

The high lift pumps discharge treated water to the distribution system via a 500 mm diameter discharge header. A venturi meter is located on the discharge header in a metering chamber in the yard to the south of the plant. Inside the pumping station on the south wall, a totalizer and circular chart recorder are provided to monitor and record treated water flow.

The treated water meter is reportedly calibrated every six months, regardless of whether flow records are considered suspect, as the meter readings are used for billing purposes. Operations staff log maximum, minimum and total flow daily.

Filler Backwash Water

Backwash water for the pressure filters is drawn from a 250 mm diameter connection downstream of the treated water meter chamber. This backwash water is metered by an orifice type meter in the low lift pump area and the metered flows are deducted from the daily treated water flow measured by the treated water meter.

Backwash water for the gravity filters is drawn from the clear well below (Clear Well 2). A 250 mm diameter connection to the distribution main on Lakeside Drive serves as standby. Neither of these sources of backwash water is metered.

Service Water

Plant service water is drawn from within the plant and is not metered.

B.2 SUMMARY OF FLOW MEASUREMENTS

Daily treated water flows pumped to the distribution system are tabulated in Table 1.1 for 1984 to 1986. These flows appear consistent for the entire record. Minimum daily flows did not always occur on weekends or statutory holidays as would normally be expected. This could be due, in part, to the fact that there is minimal industry within the service area. Therefore, water demand would not be expected to decrease on weekends as markedly as it would in a heavily industrialized area.

A monthly summary of daily average, minimum and maximum flows is given for each year at the end of Table 1.1 and in Table 1.0. The summary shows expected seasonal variations with higher average day flows throughout the summer. The highest average daily flows during the study period were recorded in the summer of 1985, however, average daily flow for the year was less than in 1986. The highest maximum daily flows occurred in July or August each year, and the lowest minimum daily flows occurred in December or January.

The following yearly summary of treated water flows indicates an increase in water flow during the study period, which is expected as the service area increases and the distribution system continues to age.

	Yearly Summary of Treated Water Flows, ML/d		
	1986	1985	1984
Average Day	6.886	6.876	6.019
Maximum Day	13.406 (July)	14.026 (Aug.)	11.497 (Aug.)
Minimum Day	4.180 (Dec.)	3.441 (Jan.)	4.023 (Dec.)

No comparison of raw and treated water flows can be made to assess the validity of the flow data.

B.3 PER CAPITA WATER CONSUMPTION

The table below summarizes per capita water consumption for the years 1984 and 1985. Population data were obtained from the Annual Operating Reports for the Grimsby Water Treatment Plant prepared by the Region. A 1986 service population was unavailable and therefore was assumed to be equal to that of 1985. The water consumption figures shown do not include plant service water or backwash water consumed at the plant.

Year	Average Day Consumption ML/d	Service Population	Per Capita Consumption (Lpcd)
1986	6.886	14,665	470
1985	6.876	14,665	469
1984	6.019	14,221	423

The per capita consumption figures for the three years are at the higher end of the range of 270-450 Lpcd normally used for design purposes. The table indicates that per capita consumption increased from 1984 to 1985 by 46 Lpcd and remained the same for the following year. This increase in per capita consumption from 1984 to 1985 could be due to several factors, including lack of rainfall during the summer of 1985, increased leakage in the distribution system, inaccuracies in water metering and population data, an increase in the unit rate of consumption and, possibly, due to an increase in the ratio of commercial/industrial to residential consumption.

Some representative per capita water consumption records (1981 data) for several communities in Ontario are as follows:

Community	Population Served	ML/d Avr. Flow	Per Capita Consumption (Lpcd)
Ancaster	11 000	2.179	198
Aurora	13 500	7.590	562
Brockville	21 500	19.413	902
Collingwood	11 100	17.251	1,554
Elliot Lake	12 893	10.410	807
Fort Erie	11 904	15.744	1,323
North Bay	45 000	20.429	454
Orangeville	13 034	4.312	331
Owen Sound	12 365	9.533	771
Pembroke	15 125	9.166	606
Smiths Falls	11 679	9.079	777
Wallaceburg	10 667	11.940	1,119

SECTION C

PROCESS COMPONENTS

SECTION C - PROCESS COMPONENTS

C.1 GENERAL

Design drawings for the Grimsby Water Treatment Plant were not available. The original water supply works, which includes the Pumping Station and three pressure filters, were expanded in 1957 with the addition of the Filter Building and the sedimentation tanks. The original works were built around 1905.

A simplified Block Flow Diagram in Figure C.1 illustrates the treatment facilities that have been provided.

The gravity filtration section of the plant utilizes the conventional treatment process consisting of in-line chemical addition, two-stage flocculation, sedimentation and gravity dual media filtration. The original design capacity is believed to have been 6,800 m^3/d when the filters were equipped with a single medium of sand. In December 1982, the original sand filters were changed to dual media, high-rate filters, whereby the design capacity was increased to the currently rated capacity of 13,600 m^3/d.

Manually cleaned, stationary raw water screens are included in the raw water intake well to screen the water prior to raw water pumping. The raw water (or low lift) pumps discharge to the flocculation/sedimentation tanks where the bulk of the particulate matter is removed. Following sedimentation, the water is filtered through two gravity filters. Filtered water discharges to clear well 2 below the filters, overflows at high level and discharges to clear well 1 in the Pumping Station. High lift pumps, with suction headers directly connected to clear well 1, deliver treated water to the distribution system.

The pressure filters in the Pumping Station, when in operation, are normally supplied with raw water from a submersible pump installed at the end of an existing pier (hence referred to as the pier pump). Raw water is thus treated, following coagulant addition downstream of the

pump, by direct filtration. The combined design capacity of the three pressure filters has been quoted as 5,700 m^3/d equivalent to 900 Imperial gallons per minute (gpm), although it is believed that the actual design flow rating is 4,900 m^3/d which is equivalent to 900 U.S. gpm. Since raw water turbidity at the pier is highly variable, it is also possible, as an alternative mode of operation to direct filtration, to discharge the flow to the flocculation/sedimentation tanks. With the use of a portable, submersible pump, pressure filters can then be loaded with settled water.

Since the pier pump installation (and the settled water pipe to the pressure filters) is not frost protected, the pressure filters are only operated seasonally during the summer. With reasonably good raw water quality, the full design capacity can be achieved which, during the summer time, increases the total plant capacity to 19,300 m^3/d.

Chemical treatment is provided in the form of:

- prechlorination of the raw water (low lift pump and pier pump discharges)
- postchlorination of filtered water
- alum coagulation to aid clarification and filtration (polyaluminum chloride was used on a trial basis in 1986)
- powdered activated carbon addition, as necessary, to control taste and odour.

C.2 DESIGN DATA

A summary of the design data and relevant plant information is presented in Table C.1. The Process Design Schematic in Figure C.4 illustrates the relationship of process components and provides a convenient overview of the sizing and capacities of these components.

a) Capacity

It is believed the plant was designed with a capacity of 6,800 m^3/d. Following the conversion of sand filters to dual media filters, in

TABLE C.1

GRIMSBY WATER TREATMENT PLANT

DESIGN DATA AND PLANT INFORMATION

PLANT ADDRESS	
Municipality	The Regional Municipality of Niagara
Plant Name	Grimsby Water Treatment Plant
Plant Address	447 Elizabeth Street Town of Grimsby, Ontario
Phone Number	(416) 945-4323
YEAR FILTER PLANT OPENED	Gravity Filter Plant opened in 1957 Pressure filters were installed in 1945, while the original water supply works (pumping station, intake) were built around 1905
WATER SOURCE	Lake Ontario
PLANT CAPACITY	
Gravity Filter Plant	
• Design Capacity	6,800 m^3/d
• Rated Capacity	13,600 m^3/d (following conversion of sand filters to dual media filters in December 1982
Pressure Filters	
• Design Capacity	4,900 m^3/d
• Rated Capacity	5,700 m^3/d
Combined Rated Plant Capacity	19,300 m^3/d

INTAKE	
Crib	- 90° elbow concrete pipe with bell mouth opening 2.44 m wide - water depth at crib is 3 to 4 m
Intake	- 450 mm dia. cast iron and steel pipe buried on lake bed - length of intake is about 230 m
• Capacity	- 159 L/s @ 0.9 m max. drawdown - volume of intake is about 36.6 m^3
Raw Water Well	- approx. dimensions: 2.74 m W x 3.66 m L x 3.96 m D; 2.74 m SWD; volume 39.7 m^3 max.
Pier Pump Intake	
• Pump	- 1 Flygt, portable, submersible pump; Model C 3152 HT, capacity 66 L/s @ 12.7 m TH; 14 kW motor; about 2 m submergence
• Pump Discharge Pipe	- 200 mm dia. x 50 m off-shore, plastic pipe laid on top of pier
RAW WATER SCREENS	- 4 stationary screen, 1 spare, manually cleaned - 2.65 m L x 1.19 m D, 6.35 mm mesh size
LOW LIFT PUMPING STATION	
Pumps	- 3 horizontal, centrifugal pumps - No. 1 - 47.3 L/s @ 12.2 m TH; electric induction motor - 11.2 kW - No. 2 - 159.0 L/s @ 11.9 m TH; dual drive - electric induction motor - 30 kW, 4 cyl. gas engine - No. 3 - 68.1 L/s @ 12.2 m TH; 4 cyl. gas engine
Station Capacity	- winter - 9,970 m^3/d firm, 23,700 m^3/d installed - summer - 15,670 m^3/d firm, 29,400 m^3/d installed

RAPID MIXING

Before 1986	- chemicals added directly to low lift pump suction pipe inlet in raw water well
After 1986	- coagulant addition point moved to Pumping Station and directly injected into raw water pipe downstream of pumps - powdered activated carbon and chlorine solution continued to be added in raw water well
Pier Pump Intake	- chemicals added by direct injection to discharge pipe downstream of pump near the plant

FLOCCULATION

Number of Tanks	- 2 tanks with 2 cells in series in each
Dimensions per Cell	- 6.10 m W x 3.05 m L x 3.50 m D, 3.05 m SWD
Volume	- 56.75 m^3 per cell, 227 m^3 total
Detection Time	- 48 min. design, 24 min. rated
Flocculators	
• Type/Number	- 2 horizontal shaft paddle flocculation units equipped with 2 sets of paddle units per cell, 1.98 m dia. x 2.44 m L
• Drive	- 2 shafts driven by single, variable speed, motorized drive through chain and sprocket assemblies by Vari-Drive
· Motor Rating	- 1.12 kW
· G Value	- 49 s^{-1} @ max. speed, about 5.1 s^{-1} at current 20% max. operating speed
· Gt Product	- 14,700 design @ 20% speed, 7,350 rated @ 20% speed

SEDIMENTATION

Number of Tanks	- 2
Dimensions per Tank	- 6.10 m W x 24.38 m L x 3.50 m D, 3.05 m SWD
Volume	- 453.6 m^3 per tank, 907.2 m^3 total
Detention Time	- 3.2 h design, 1.6 h rated
Surface Overflow Rate	- 0.95 m/h design, 1.9 m/h rated
Effluent Pump	- 1 Flygt, portable, submerisble pump, Model C 3152 HT capacity 66 L/s @ 12.7 m TH, 14 kW motor

GRAVITY FILTERS

Number of Filters	- 2 high rate, dual media filters (anthracite and sand)
Dimensions	- 5.5 m W x 5.5 m L x 3.07 m D
Surface Area	- 30.25 m^2 per filter, 60.5 m^2 total
Filter Rate	- 4.7 m/h design, 9.4 m/h rated flow
Rate of Flow Controller	- self-powered mechanical rate of flow control valve by Simplex
Media	- 380 mm anthracite, E.S. = 0.85 to 0.95, U.C. ≤1.7
	- 250 mm sand, E.S. = 0.53 - 0.60 mm, U.C. = 1.4
	- 250 mm graded gravel, 5 layers of 25 mm to 1.8 mm size
Underdrains	- Leopold Block
Surface Wash	- rotary, straight arm Palmer sweeps, 5.03 m dia., 1 per filter
Wash Water Rate	- 600 mm rise per minute max. or 36 m/h @ 11.6 m TH
Trough Elevation	- 710 mm above top of anthracite
Backwash Pump	- 1-2 speed, vertical turbine pump capacity 303 L/s max. @ 11.6 m TH, 44.76 kW motor

PRESSURE FILTERS

Number of Filters	- 3 single medium sand pressure filters by Permutit
Dimensions	- 2.44 m dia. x 7.62 m L each
Surface Area	- 14 m^2 per filter, 42 m^2 total
Filter Rate	- 4.88 m/h design, 5.65 m/h rated
Wash Water Rate	- 36.6 m/h rise rate design
· Source	- 200 mm dia. distribution system header

CLEAR WELL

Clear Well 1	- open top, below pressure filters in Pumping Station, 480 m^3 capacity
Clear Well 2	- below gravity filters in Filter Building, 355 m^3 capacity
Total Storage Capacity	- 835 m^3 (fixed storage)

HIGH LIFT PUMPS

Type/Number	- 1-2 stage, horizontal, centrifugal pump, electric induction motor 3 horizontal, centrifugal pumps, 2 with electric induction motors and 1 with diesel engine drive 1 vertical turbine pump, with high thrust electric motor - No. 1 - 28.4 L/s @ 64 m TH (33.5 m for single stage), 56 kW motor - No. 2 - 68.2 L/s @ 97.5 m TH, 93.3 kW motor - No. 3 - 68.2 L/s @ 97.5 m TH, 93.3 kW motor - No. 4 - 68.2 L/s @ 97.5 m TH, 6 cyl. diesel engine drive - No. 5 - 56.8 L/s @ 97.5 m TH, 93.3 kW motor
Station Capacity	- 19,150 m^3/d firm, 25,000 m^3/d installed

CHEMICAL PROCESSES

Chlorination	
• Chemical Applied	- gaseous chlorine in solution form
• Prechlorination	- low lift pumps common discharge header - pier pump discharge header
• Postchlorination	- inlet to clear well 1: 1) in pipe from gravity filters, 2) to bottom of well
• Storage	- 68 kg chlorine cylinders, 5 in service, 1 spare, 7 empty
• Scale	- 3 - 2 cylinder scales by W & T, 2 for pre- and 1 for postchlorination service
• Chlorinators	- 2 - 22 kg/d V-Notch, A731 W & T chlorinators for prechlorination service 1 - 9 kg/d V-Notch, V-100 W & T chlorinator for postchlorination service
Coagulation	
• Chemical Applied	- before January 1986 liquid alum (aluminum sulphate) was used as the coagulant - after January 1986 polyaluminum chloride (PACl) was used
• Application Point	- before 1986 - at pump suction inlet in raw water well and in discharge header from pier pump - after 1986 - application point in raw water well was moved to common discharge header from low lift pumps in Pumping Station
• Storage	- 1 - 20.5 m^3 bulk storage tank, 2.74 m dia. x 3.66 m H - 1 - 175 L day tank, 0.56 m dia. x 0.86 m H
• Transfer Pump	- 1 coagulant transfer pump to day tank, manually controlled, 50 mm dia. suction x 38 mm dia. discharge

CHEMICAL PROCESSES (cont'd)

Coagulation (cont'd)	
• Metering Pump	
· Before 1987	- 1 - 4.9 L/h W & T A745 diaphragm pump (duty pump), 60 W motor - 2 - 9 L/h to 33 L/h BIF 1210 - 04 diaphragm pumps (standby), 124 W motor - pumps include 3-step pulley for manual speed adjustment - stroke can be adjusted manually over 0-100% range
· After 1987	- a 2nd coagulant metering station was established in the low lift pump room of the Pumping Station including: 1 - 175 L day tank, 0.56 m dia. x 0.86 m H, 1 W & T pump (from Screen House), and 1 additional BIF 1210-04 diaphragm pump similar in capacity to existing
• Dry Alum Feeder	- 1 W & T dry alum feeder is available in the Screen House for use during emergency conditions
Taste and Odour Control	
• Chemical Applied	- powered activated carbon in slurry form applied to the raw water well
• Storage	- bagged storage of powdered activated carbon
• Feeder	- 1 BIF screw type dry volumetric feeder with slurrying tank, 45 kg max. Toledo scale, hopper, 44 mm dia. feed screw, 130 L slurry tank

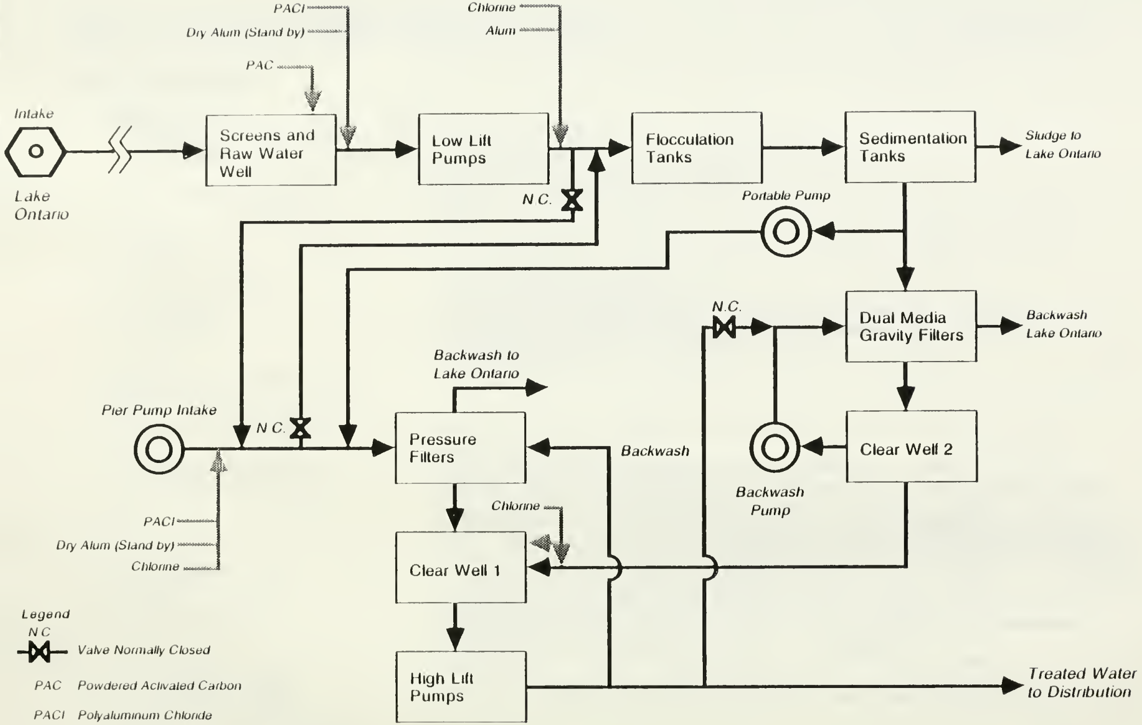

Figure C.1
GRIMSBY WATER TREATMENT PLANT
Block Flow Diagram

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December of 1982, the currently rated plant capacity of 13,600 m^3/d was established.

With the installation of the pier intake and three pressure filters, with a design rating of 4,900 m^3/d, the plant capacity during the summer time was initially increased from 6,800 m^3/d to 11,700 m^3/d.

The pressure filters were found to be capable of some overload capacity and have thus been rated at 5,700 m^3/d. During the summer, therefore, with good raw water quality the existing combined rated plant capacity of the Grimsby Water Treatment Plant is 19,300 m^3/d.

The maximum average day raw water flow treated at the plant was established in August 1985 at 14,026 m^3/d.

b) Capacity Limitations

Pressure filters operate on the principle of direct filtration. Capacity for this process is sensitive to raw water quality, turbidity and algae content, and the level of the coagulant dose. With high raw water turbidity (generally above 15 NTU), therefore, the rated capacity of 5,700 m^3/d cannot be sustained on a continuous basis. In ar attempt to overcome this problem, flow from the pier pump intake can be re-directed to the pretreatment (flocculation and sedimentation) section of the main plant before filtering by the pressure filtration units.

With the main treatment plant (pretreatment followed by gravity filtration), problems have been encountered at high flows during the summer months (at the rated plant capacity of 13,600 m^3/d) with impaired raw water quality (high raw water turbidity and high algae counts). Problems encountered stem from the poor performance of the sedimentation tanks which are hydraulically overloaded, and the resultant high solids loadings of the filters. A further operational problem exists during backwashing of the two filters. With one filter out of service, raw water flow has to be reduced in order to prevent the in-service filter from being significantly overloaded. Also, during the winter capacity is seriously reduced (in the order of 5,000 to 7,000 m^3/d) as a result of frazil ice blocking the intake and because of poor performance achieved in the coagulation and flocculation of cold water.

C.3 PROCESS COMPONENT INVENTORY

a) Intake

The plant is served by two intakes, the main intake which is operational all year, and the pier pump intake which can be operated only during the warm weather period of the year.

The main intake (or gravity intake) consists of sections of 450 mm dia. cast iron and steel pipes buried on the lake bottom. The intake pipe is about 230 m long and is fitted with a bell mouth concrete intake crib. The crib opening is 2.44 m in diameter and is located in 3 to 4 m of water. The original bar screen over the opening has been removed because the screen tended to plug up with frazil ice.

The main intake capacity is 159 L/s (13,738 m^3/d) at a maximum drawdown of 0.9 m and has a volume of about 37 m^3.

The raw water suction well in the Screen House has a capacity of about 40 m^3. Facilities exist for backflushing the intake.

Problems have been encountered with the operation of the gravity intake because of its location in shallow water, close to the shore, and next to the outlet of the Forty Mile Creek. During the winter frazil ice is a serious problem that affects the capacity of the intake. At other times, especially during and after rainstorm events in the fall and spring, raw water quality if subject to wide fluctuations in turbidity which can affect the filtered water effluent quality.

The pier pump intake consists of a submersible pump, capacity 66 L/s at 12.7 m total head, with a 200 mm dia. forcemain laid on top of the pier. The pump at the end of the pier is about 50 m off-shore and is located in about 2 m of water.

The pier pump intake, although acceptable in case of emergencies, cannot be considered suitable as a permanent arrangement since the lake water quality at the location of the pump is highly variable and subject to contamination from on-shore runoff and other point-source discharges.

b) Raw Water Screens

Stationary raw water screens are installed in the raw water well. Four screens measuring 2.65 m long x 1.19 m deep are stacked vertically, one on top of the other, to separate the inlet from the pump suction well. Screens are fabricated of wooden frames with 5.35 mm wire mesh, and are cleaned manually with a hose on the outside of the Screen House.

c) Low Lift Pumping

Three low lift pumps are installed in the original Pumping Station. The pumps are of the horizontal, centrifugal design and take suction from the raw water well in the Screen House. A common 250 mm dia. suction header serves pumps 1 and 3 and a 400 mm dia. header serves pump 2.

Pump drivers include electric induction motors and direct gasoline engine drives as shown in Table C.2 and listed below:

- Pump 1 - 12.2 kW electric motor

- Pump 2 - dual drive, 30 kW electric motor and 4 cylinder gasoline engine

- Pump 3 - 4 cylinder gasoline engine.

The capacity of the low lift pumps is given in Table C.2.

The portable pier pump, also listed in Table C.2, has a submersible electric motor rated at 14 kW, and a capacity of 66 L/s at 12.7 m total head.

Exclusive of the pier pump, the installed low lift station capacity is 23,700 m^3/d. With the largest pump out-of-service, the firm pumping capacity is 9,970 m^3/d.

The pumps are operated manually from local individual pump start/stop pushbutton stations. Pump selection is based on the water level in clear well 1 obtained from a level indicator located in the low lift pump room. There are no alarms to indicate high or low level in the clear well.

d) Rapid Mixing

There are no formal rapid mixing facilities at the Grimsby Water Treatment Plant. Before 1987 chemicals in solution form were added to the process flow at the following points:

- alum or PACl: discharged to the pump suction inlet in the raw water well

- dry alum: mixed with water to form solution/slurry and dripped onto the water surface in the raw water well

- powdered activated carbon: slurried and dripped onto water surface in raw water well

- chlorine solution
  - prechlorination: injected into common discharge header from low lift pumps

  - postchlorination: direct discharge to inlet end of clear well 1

- pier pump intake: coagulant and chlorine solution injected into discharge pipe downstream of pump (under the lawn before the water enters the plant).

TABLE C.2

RAW WATER PUMPS

Pump No.	Capacity L/s	Head m	Type	Motor Rating, kW	Manufacturer Pump/Motor
1	47.3	12.2	horizontal, centrifugal	11.2	DeLaval Westinghouse
2	159.0	11.9	horizontal, centrifugal	30 plus gas drive	DeLaval Westinghouse motor Continental Motors engine
3	68.1	12.2	horizontal, centrifugal	gas drive	DeLaval Fairbanks Morse engine
Pier Pump	66	12.7	submersible	14	Flygt

Notes:

Installed Station Capacity (excluding pier pump): 23,700 m^3/d

Firm Station Capacity: 9,970 m^3/d

After 1986, a second coagulant metering station, coagulant day tank and two metering pumps, for the main treatment stream was established in the low lift pump room of the Pumping Station. From then on, coagulant solution was applied by direct injection into the common raw water discharge header immediately downstream of the pumps. The application of coagulant to the pier pump discharge was not changed.

Originally, mixing of coagulant and raw water was achieved in the suction piping, the low lift pumps, and in the discharge piping to the flocculation basins. The vigorous mixing achieved in the volutes of the pumps was found to be detrimental to the pre-formed floc hence the application point was relocated after the pumps.

e) Flocculation

Each of the two flocculation tanks is divided into two cells for two-stage mechanical flocculation.

Cell dimensions are:

- cell 1: 6.10 m W x 3.05 m L x 3.50 m D
- cell 2: 6.10 m W x 3.05 m L x 3.50 m D.

The side water depth (SWD) at the design flow rate is 3.05 m.

Flocculating mechanisms consist of two horizontal shaft paddle flocculation units equipped with two sets of paddle units per cell. The two flocculators are driven by a single, variable speed, motorized drive through chain and sprocket assemblies.

The motor rating of the flocculator drive and process design parameters are presented in Tables C.3 and C.4. It will be noted that the flocculator achieves a mean velocity gradient of 5.1 s^{-1} in each cell at the current speed setting of 2 on the vari-drive. The detention time

varies with flow and ranges from 78 minutes to 24 minutes for minimum to maximum flows as represented by the minimum day for 1986 and the rated plant capacity of 13,600 m^3/d. At the design flow rate the detention time is 48 minutes. The Gt product varies with detention time and is listed in Table C.4.

f) Sedimentation

Sedimentation tanks each measure 6.10 m wide x 24.38 m long x 3.50 m high and have an operating side water depth of 3.05 m at the design flow rate. The volume per tank is 453.6 m^3 and the resultant detention times and overflow rates for the various plant flows are as follows:

Plant Flow, m^3/d	Detention Time, h	Surface Overflow Rate, m/h
4,180 - minimum	5.2	0.59
6,800 - design	3.2	0.95
13,600 - rated	1.6	1.90

The sedimentation tank outlet consists of three effluent launders with a total weir length of 17.68 m and a resultant weir overflow rate of 192.3 m^3/d per metre length of weir.

Settled water is conveyed by gravity to the gravity filters. In addition, a portable submersible pump has been installed in the sedimentation tank effluent channel whereby settled water can be pumped to the pressure filters. The system is not frost protected and is only used during the summer as required. The pump, Flygt Model C 3152 HT, has a capacity of 66 L/s at a total head of 12.7 m; the motor rating is 14 kW.

Sedimentation tanks are open-top, outdoor tanks, without sludge collection mechanisms.

TABLE C.3

FLOCCULATOR SPECIFICATION

Manufacturer	Vari-Drive
Type	Horizontal shaft paddle flocculator
Number of units	2, one each with common shaft serving primary cells of tanks 1 and 2 and secondary cells of tanks 1 and 2
Paddle units	2 sets per cell, 1.98 m dia. x 2.44 m L, with 4 pipe arms containing 2 paddles on each arm consisting of 50 mm x 150 mm wooden planks
Drive	Single, variable speed, motorized drive unit with chain and sprocket assemblies
Motor rating	1.12 kW
Speed settings	0 to 9, by selector switch on speed reduction gear unit
G Value	49 s^{-1} maximum, other calculated values are:
	- 26.7 s^{-1} at speed setting 6
	- 14.6 s^{-1} at speed setting 4
	- 5.1 s^{-1} at speed setting 2

TABLE C.4

FLOCCULATION PROCESS DESIGN

Plant Flow m^3/d	Detention Time, min.	Speed Setting	G Value s^{-1}	Gt Product
4,180 - minimum[1]	78	2	5.1	23,900
6,800 - design[2]	48	2	5.1	14,700
13,600 - rated[3]	24	2	5.1	7,350

[1] Minimum day for 1986

[2] Approximately equal to 1986 average day of 6,886 m^3/d

[3] Approximately equal to 1986 maximum day of 13,406 m^3/d

g) Filters

(i) Gravity Filters

The main plant has two dual media, gravity filters located in the Filter Building. They are square in plan dimensions and include one wash water gullet along the inlet side of each filter. Filter controls are of the mechanical design by the Simplex Valve Company and feature an operating console at the front (outlet end) of the filter on the main floor and a self-powered mechanical rate of flow control valve on the effluent piping in the basement pipe gallery. The filters operate on the principle of constant rate filtration.

Filter dimensions are 5.5 m wide by 5.5 m long by 3.07 m deep; the wash water gullet is 0.91 m wide. The wash water trough weir elevation is 1.854 m above the floor of the filter bay and 0.710 mm above the top of the anthracite.

Each filter has a surface area of 30.25 m^2 and the total area for the two filters is 60.5 m^2. The filter rate at the design flow rate is 4.7 m/h and 9.4 m/h at the rated plant capacity.

The 250 mm deep Leopold Block underdrains are covered with five layers of graded gravel ranging in size from 25 mm to 1.8 mm with a total depth of 250 mm. The filter media consists of a layer of sand and anthracite with the following characteristics:

Media	Depth, mm	E.S., mm	U.C.
anthracite	380	0.85 to 0.95	<1.7
sand	250	0.53 to 0.60	1.4

Each filter is equipped with one 5.03 m diameter rotary, straight arm, Palmer sweep surface agitator. Filters are backwashed by a single two speed wash water pump capable of a maximum wash water rise rate of 600 mm per minute equivalent to 36 m/h.

Wash Water System

The filter pipe gallery includes one two speed vertical turbine pump by Peerless Pump Division, driven by an electric induction motor manufactured by U.S. Motor Corp.

The pump has a maximum capacity of 303 L/s at a total head of 11.6 m. The motor rating is 44.76 kW. The pump draws water from the clear well below the filters (clear well 2). A 250 mm diameter connection to the distribution main on Lakeside Drive serves as standby.

Filter Instrumentation

No analogue or digital filter instrumentation equipment exists. Filters are operated manually from the filter console. A self-powered mechanical filter rate controller (Simplex valve) is installed on the filter effluent piping.

(ii) Pressure Filters

In parallel with the gravity filtration plant, there are three pressure filters installed in the Pumping Station. These filters, manufactured by The Permutit Company, are 2.44 m in diameter by 7.62 m long, and have an area of 14 m^2 per filter. They include a single layer of sand and operate at a design filter rate of 4.88 m/h.

Backwash water is drawn from a 200 mm diameter main connected in the yard to the high lift pump discharge pipe downstream of the treated water flow meter. Sufficient flow is available to meet the design wash water rate of 36.6 m/h. Backwash water consumption is metered by a BIF orifice type flow meter installed in the 200 mm diameter supply main.

h) Clear Well

The plant has two clear wells, clear well 1 below the pressure filters in the Pumping Station with a capacity of 430 m^3 and clear well 2 below

the gravity filters in the Filter Building with a capacity of 355 m^3. The combined clear well storage capacity is 835 m^3 which provides a detention time of 1.47 h at the rated plant capacity of 13,600 m^3/d.

i) High Lift Pumping

The high lift pump room in the Pumping Station is equipped with four horizontal centrifugal pumps, three of which are driven by electric induction motors and one by a direct coupled diesel engine drive. A fifth high lift pump is installed in the low lift pump room above the clear well. this pump is a vertical turbine pump driven by a high thrust electric motor. Pump capacities and motor ratings are tabulated in Table C.5.

The installed high lift station capacity is 25,000 m^3/d at a total head of 97.5 m except for pump 1 which has a rated head of 64 m. With the largest pump out of the service, the firm station capacity is 19,150 m^3/d.

No standby power is available to run treated water pumps during an emergency power outage. Standby capacity of 68.2 L/s at the design head or 5,900 m^3/d is provided by pump 4 with the direct diesel engine drive.

Pumps discharge into a 500 mm diameter distribution header. A venturi flow meter is located on the header in a chamber in the yard to the south of the Pumping Station. In the pump room a BBC Brown Boveri totalizer and circular chart recorder are provided to monitor and record treated water flow.

Local pushbutton stations are provided for manual operation of the pumps.

j) Backwash Treatment and Sludge Disposal

There are no facilities for the treatment and disposal of plant process wastes.

Raw water screens are washed outdoors where the wash water and screened solids just discharge to the ground.

Backwash water from the pressure filters and the gravity filters are discharged via individual shore outfalls to the lake.

Similarly, settled sludge from the sedimentation tanks is discharge via a separate shore outfall to the lake. This is done intermittently four times per year.

Reference is made to Figure C.3 for an illustration of the locations of these outfalls.

k) Standby Power

There is no standby power at the plant. Two low lift pumps and one high lift pump can be operated during power outages with gasoline and diesel engine drives.

C.4 CHEMICAL SYSTEMS

C.4.1 LIQUID CHEMICAL FEED EQUIPMENT

a) Liquid Coagulant

Before January 1986, liquid alum was used as the coagulant. For the remainder of 1986 polyaluminum chloride (PACl) was used on a trial basis. The two coagulants have similar physical properties and the same storage and feed equipment was used. The equipment that was in use at the time of the site inspection on December 16, 1986 is as follows:

- 1 - 20.5 m^3 bulk, PVC lined, wood stave storage tank, 2.74 m dia. by 3.66 m high

- 1 - 175 L FRP day tank, 0.56 m dia. by 0.86 m high

TABLE C.5

TREATED WATER PUMPS

Pump No.	Capacity L/s	Head m	Type	Motor Rating kW	Manufacturer Pump Motor
1	28.4	64	2 stage, horizontal, centrifugal	56	DeLaval Westinghouse
2	68.2	97.5	horizontal, centrifugal	93.3	DeLaval Westinghouse
3	68.2	97.5	horizontal, centrifugal	93.3	DeLaval English Electric Co.
4	68.2	97.5	horizontal, centrifugal	6 cyl. diesel	DeLaval Continental Diesel
5	56.8	97.5	vertical turbine	93.3	Peerless U.S. Electric Motors

Notes:

Installed Capacity: 25,000 m^3/d

Firm Capacity: 19,150 m^3/d

- 1 coagulant stock solution transfer pump

- 3 chemical dosage pumps:

  · 1 - 4.9 L/h Wallace and Tiernan A745 diaphragm pump
  · 2 - 9.0 to 33 L/h BIF 1210-04 diaphragm pumps

- 1 Wallace and Tiernan dry alum volumetric feeder with slurry tank.

Dosage pumps include 3-step pulleys for manual speed adjustment. The pump strokes are manually adjustable over a 0 to 100% range.

All equipment was located in the Screen House and coagulant was applied to the raw water well and to the pier pump discharge.

The feed rate of each pump was set by manually adjusting the speed and stroke length of the pump. No controls for the automatic pacing of coagulant dosage were provided.

During 1986, with PACl as the coagulant, dry alum was used as a standby coagulant.

Subsequently, a second coagulant feed station was established in the low lift pump room of the Pumping Station This station consists of one day tank of similar capacity to the original tank in the Screen House and two chemical dosage pumps, the Wallace and Tiernan pump from the Screen House and one additional BIF 1210-04-9101 pump with the same capacity as the two existing pumps.

At the new location chemical coagulant solution is applied by direct injection into the common discharge header from the low lift pumps. Again, dosage is manually set by selecting a pump speed (one of three) and adjusting the stroke length of the pump. No proportional-to-flow pacing equipment was provided.

b) Powdered Activated Carbon

A powdered activated carbon slurry can be applied to the raw water well for the control of taste and odour.

Feed equipment available consists of a BIF dry volumetric feeder with slurrying tank situated over the raw water well. Dosage is manually set by the operator based on the treated water flow rate.

C.4.2 GASEOUS CHEMICAL FEED EQUIPMENT

Chlorine Gas

Chlorine gas in solution form is applied for pre and postchlorination. Application points are:

- prechlorination: 1) in common discharge header of low lift pumps
  2) in discharge line from pier pump

- postchlorination: 1) at inlet pipe to clear well 1
  2) directly to bottom of clear well 1 at inlet.

Storage Equipment

- 13 - 68 kg chlorine cylinders, 5 in service, 1 spare, 7 empty
- 3 - 2 cylinder weigh scales by Wallace and Tiernan, 2 for prechlorination service and 1 for postchlorination.

Feeders

- 2 - 22 kg/d Wallace and Tiernan V-Notch, A731, chlorinators for prechlorination service

- 1 - 9 kg/d Wallace and Tiernan V-Notch, V-100, chlorinator for postchlorination service.

Feeders are equipped with proportional-to-flow controls. All three chlorinators are interchangeable by means of valving on the chlorine feed piping.

The chlorine room, located on the west wall of the Pumping Station, is monitored for gas leakage by a "Chloralert" Fisher and Porter gas in air detector.

C.5 SAMPLING

Raw and treated water taps are available at the laboratory sink. All other water samples, required for process monitoring are collected manually.

C.6 PROCESS AUTOMATION

No instrumentation equipment has been provided for automatic control of the operation of the water treatment plant and pumping equipment apart from the chlorinators, which are equipped with automatic quantitative pacing controls relative to treated water flow.

All plant operations, therefore, are essentially manual. A self-powered mechanical rate control valve, one on each of the discharge headers from the gravity filters, maintains constant filter rate.

This valve will automatically close when a backwash is initiated. Upon filter start-up the valve will automatically open at a gradual rate until the established filter rate is reached.

C.7 EMERGENCY STANDBY OPERATION

In the event of a power failure plant operations will shut down. The diesel driven high lift pump can be operated for some time until the volume in clear well 1 is depleted.

Although two of the low lift pumps are equipped with gasoline powered engine drives, they cannot be used during a power outage because chemical feed equipment would be out of service.

C.8 DRAWINGS

a) Plant Drawings

Design drawings were not available for the Grimsby Water Treatment Plant. A sketch of the general plant layout and a process and piping diagram were prepared for the purpose of this report. These drawings are included herein as Figures C.2 and C.3.

b) Process Design Schematic

Figure C.4 presents a process design schematic of the Grimsby plant.

c) Plant Photographs

A photographic record of the plant is included herein following Figure C.4. The record is preceded by a photograph index.

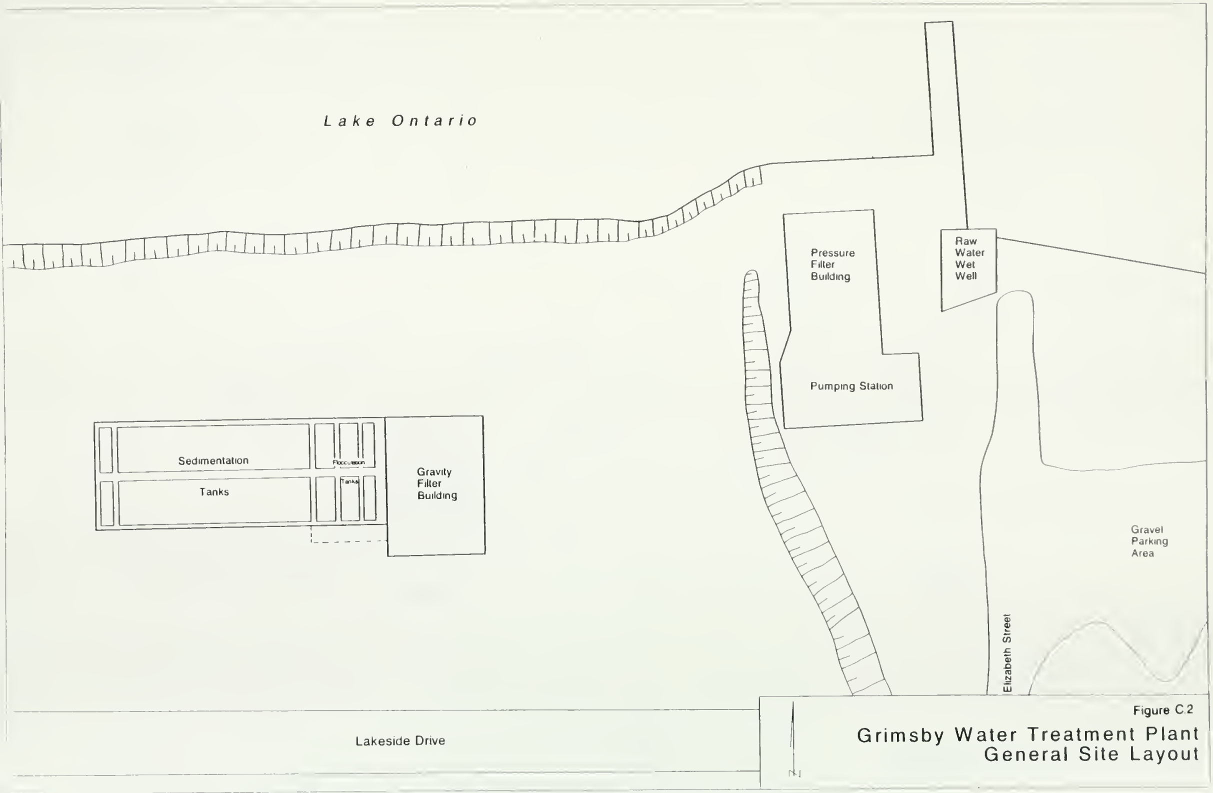


Figure C.2
Grimsby Water Treatment Plant
General Site Layout

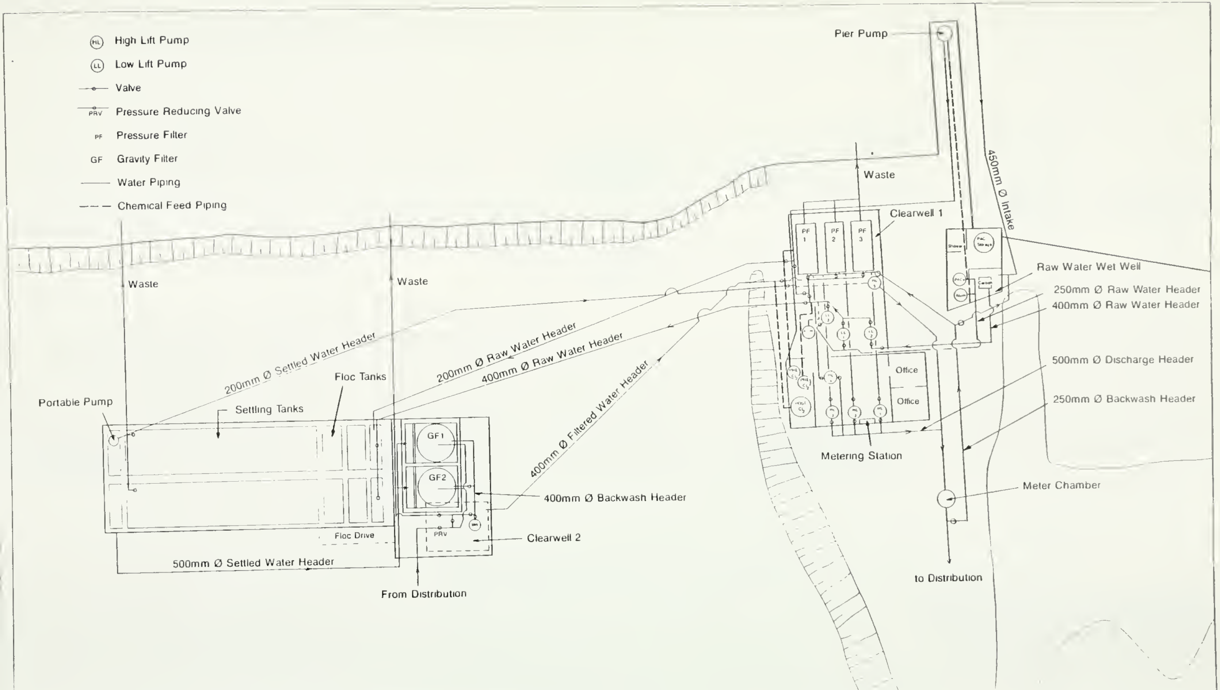


Figure C3

Grimsby Water Treatment Plant Process and Piping Diagram

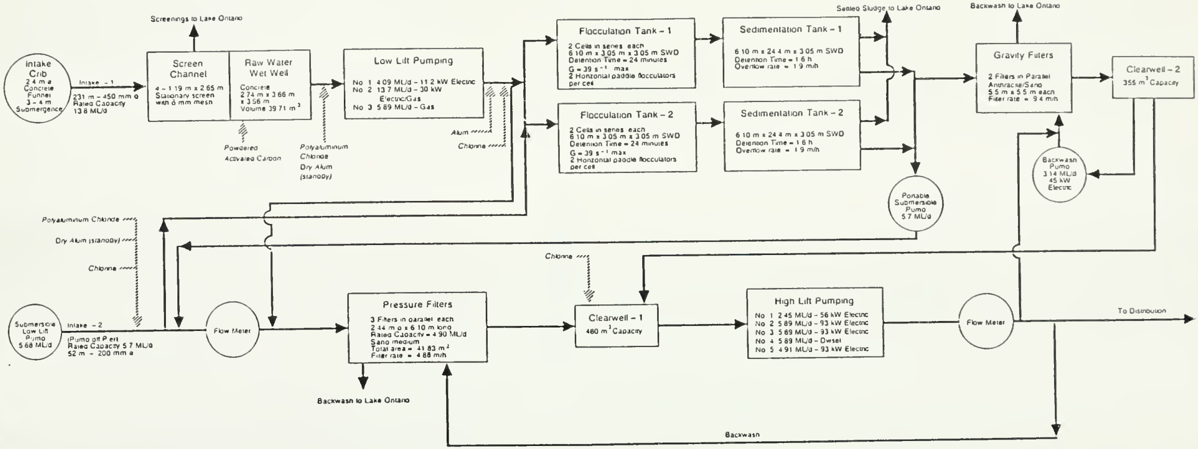


Figure C.4
GRIMSBY WATER TREATMENT PLANT
Process Design Schematic

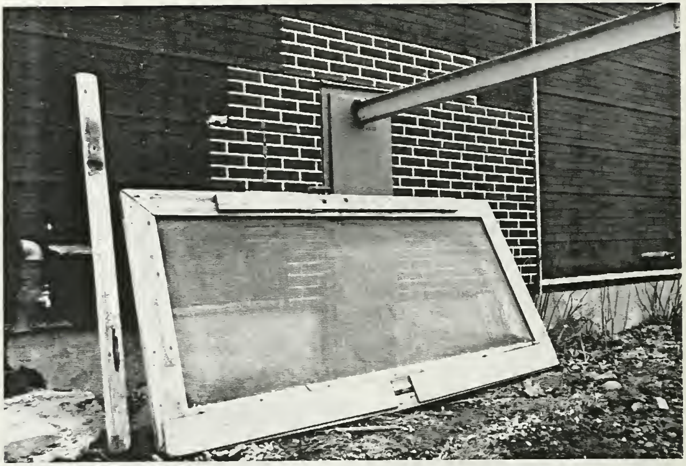
PHOTOGRAPHIC RECORD

Grimsby W.T.P. - Photograph Index

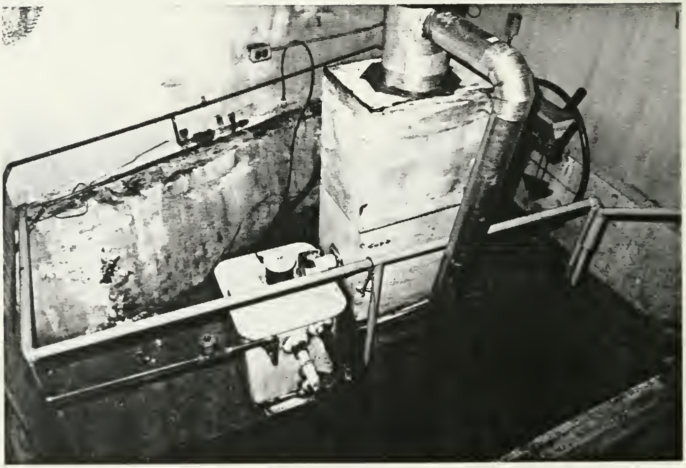
Photograph	Subject
1	Grimsby Water Treatment Plant - Original Pumping Station Including Pressure Filters
2	Gravity Sedimentation and Filtration Plant - Filter Building and Sedimentation Tanks in Foreground
3	Raw Water Screen and Wall Access to Screen Channel
4	Raw Water Wet Well and Carbon Feeder
5	Polyaluminum Chloride Bulk Storage Tank
6	Polyaluminum Chloride Day Tank and Metering Pumps
7	Dry Alum Feeder
8	Dual Drive Low Lift Pump - Electric/Gas
9	Low Lift Pump Discharge Piping and Raw Water Meter
10	Pressure Filters in Low Lift Pump Room
11	Inlet Channel to Flocculation Tanks
12	Flocculation Tanks
13	Sedimentation Tanks and Covered Overflow Wiers at Discharge
14	Gravity Filters and Filter Console
15	Filter Rate Control Valve in Pipe Gallery
16	Pre-Chlorination System for Pier Pump Discharge
17	Chlorine Room - Pre - and Post Chlorinators with 2-Cylinder Scales
18	Jar Tester
19	Laboratory Counter in High Lift Pump Room
20	High Lift Pump with Diesel Engine Drive
21	High Lift Pump
22	Treated Water Flow Metering Station

Photograph 1: Grimsby Water Treatment Plant - Original Pumping Station Including Pressure Filters

Photograph 2: Gravity Sedimentation and Filtration Plant - Filter Building and Sedimentation Tanks in Foreground

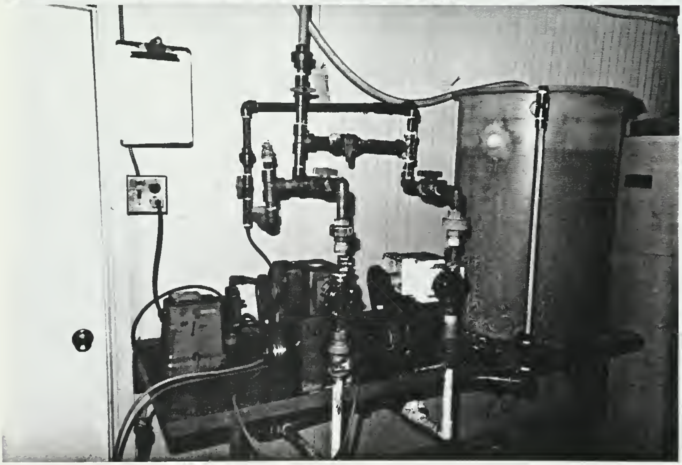


Photograph 3: Raw Water Screen and Wall Access to Screen Channel



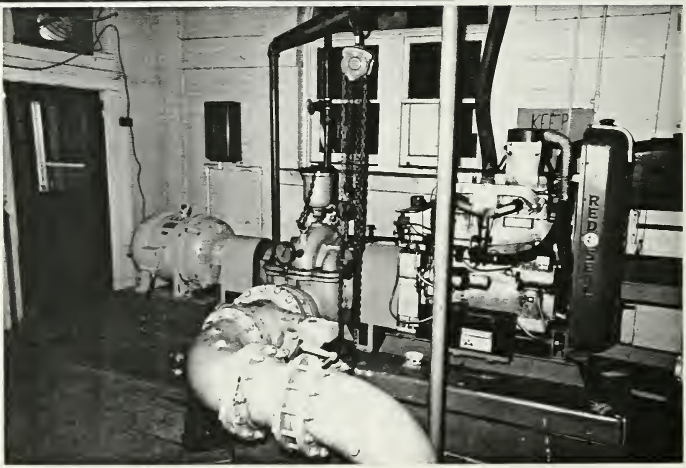
Photograph 4: Raw Water Wet Well and Carbon Feeder

Photograph 5: Polyaluminum Chloride Bulk Storage Tank

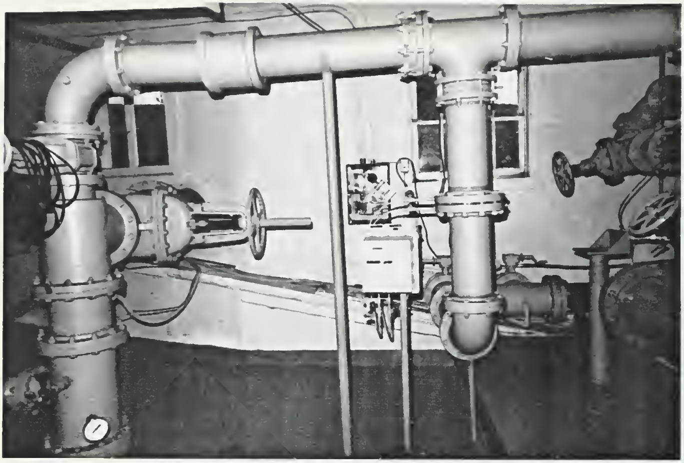


Photograph 6: Polyaluminum Chloride Day Tank and Metering Pumps

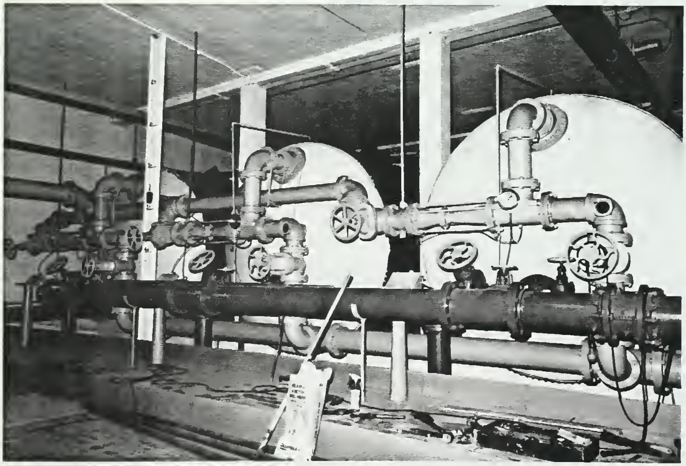
Photograph 7: Dry Alum Feeder



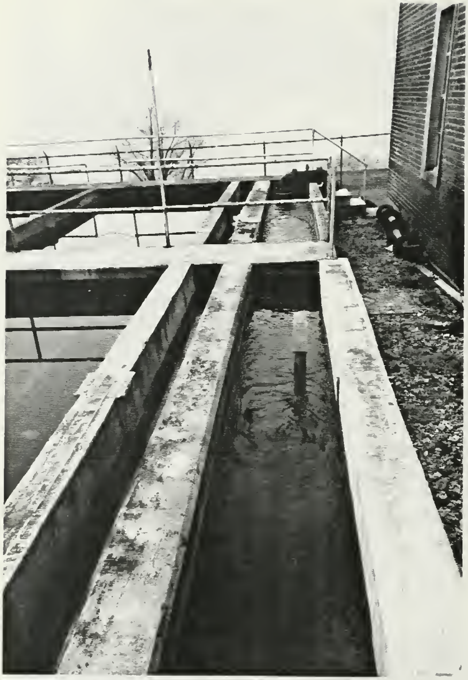
Photograph 8: Dual Drive Low Lift Pump - Electric/Gas



Photograph 9: Low Lift Pump Discharge Piping and Raw Water Meter



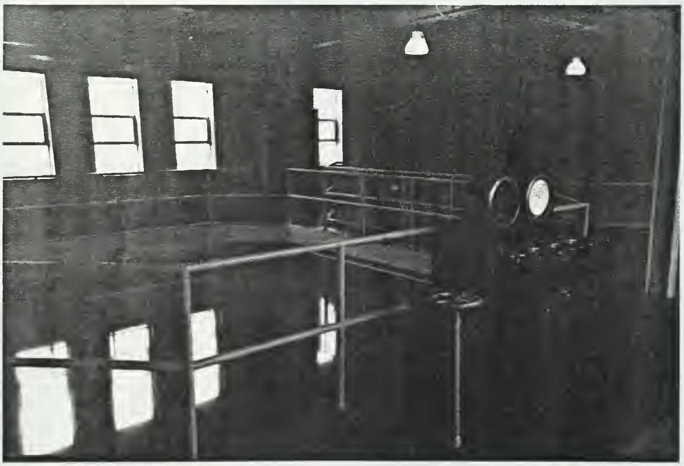
Photograph 10: Pressure Filters in Low Lift Pump Room



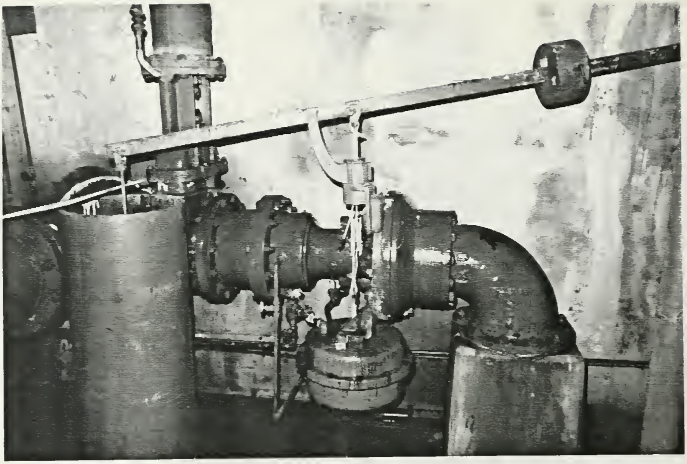
Photograph 11: Inlet Channel to Flocculation Tanks

Photograph 12: Flocculation Tanks

Photograph 13: Sedimentation Tanks and Covered Overflow Weirs at Discharge

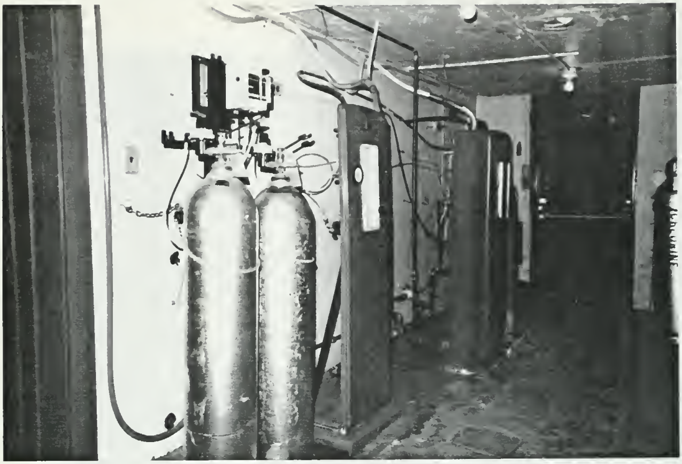


Photograph 14: Gravity Filters and Filter Console

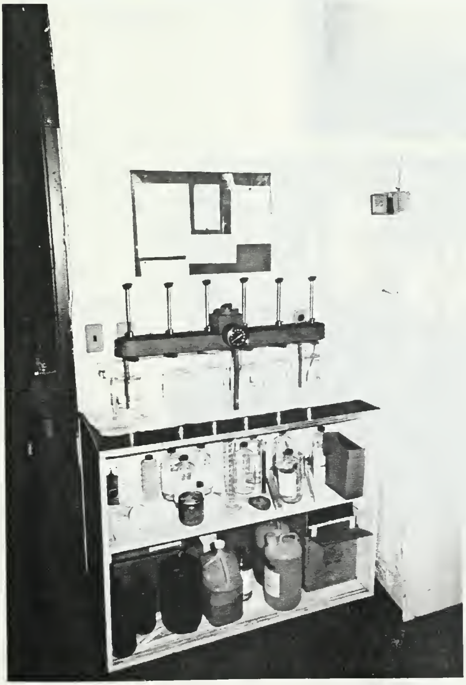


Photograph 15: Filter Rate Control Valve in Pipe Gallery

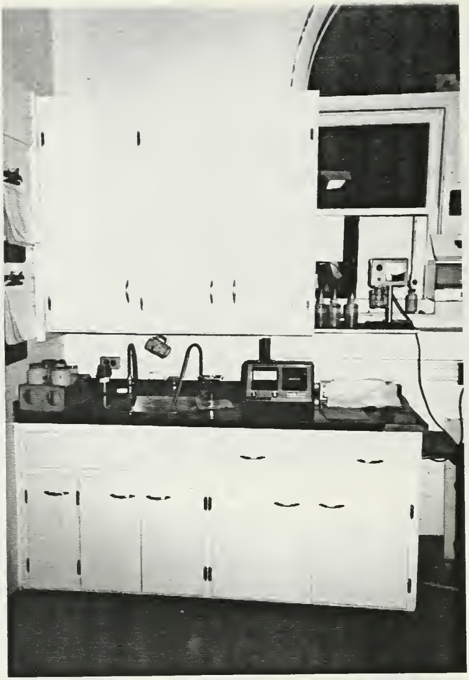
Photograph 16: Pre-Chlorination System for Pier Pump Discharge



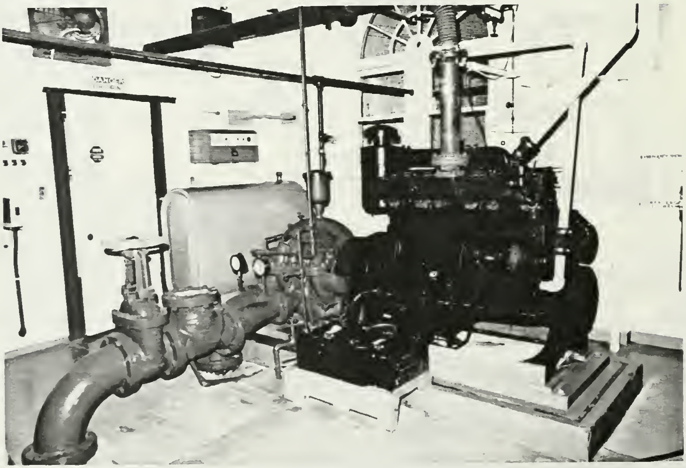
Photograph 17: Chlorine Room - Pre- and Post Chlorinators with 2-Cylinder Scales



Photograph 18: Jar Tester

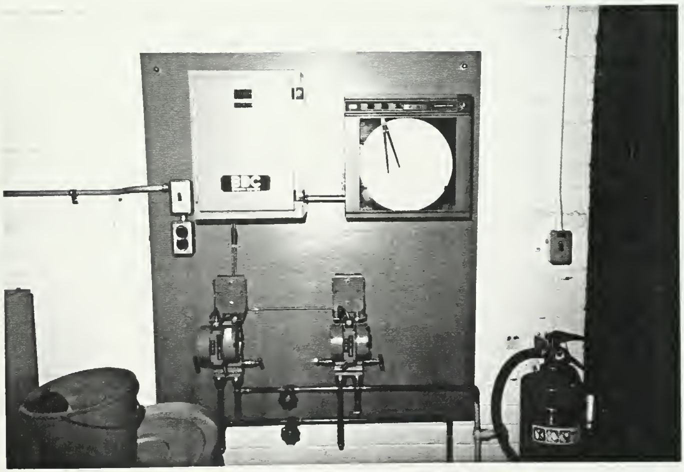


Photograph 19: Laboratory Counter in High Lift Pump Room



Photograph 20: High Lift Pump with Diesel Engine Drive

Photograph 21: High Lift Pump



Photograph 22: Treated Water Flow Metering Station

SECTION D

PLANT OPERATIONS

D. PLANT OPERATION

D.1 GENERAL DESCRIPTION

The plant is operated on a manual basis. No analogue supervisory and/or control system exists. All equipment and process operation including the operation of chemical feed systems must be initiated on a manual basis.

Supervisory and operating staff consists of the following:

- Manager, Plant Operations
- Superintendent, Area 3 (Water)
- Foreman, Area 3 (Water)
- Senior Plant Operator
- 3 Plant Operators

Water quality control analyses, described later in Section D.6, and jar tests are performed by the operators at the plant.

The plant operates on the basis of 2-12 hour shifts per day, 7 days per week. One operator is on duty during each shift. During the day shift the operator is supported by the Superintendent and Area Foreman.

The plant operator monitors plant operations, carries out water quality tests, sets chemical feed rates, maintains the daily log sheet, is in charge of receiving chemical deliveries, and backwashes filters.

D.2 FLOW CONTROL

a) Low Lift Pumps

Raw water pumps are selected manually, based on the water level in clear well 1 which is obtained from a level indicator in the low lift pump room. No alarms are provided to indicate high or low level in the clear well.

b) Filter Rate Control

The pressure filters at the plant are operated manually, and no control of filter rate is available, other than the limited control provided by partially opening the gate valves on the raw water header piping. Operating staff have no means to monitor the distribution of flow to the three pressure filters, which are operated in parallel.

A self-powered mechanical filter rate controller is provided on each gravity filter discharge pipe. The filter rate is set manually by positioning a counterweight on a graduated weigh beam.

c) High Lift Pumps

High lift pumps are selected manually based on pressure in the main discharge header. The operator on duty selects pumps to maintain a discharge pressure of 862 kPa (125 psi). The level in the system reservoir at Park Road is monitored and recorded by a remote circular chart recorder in the plant office. However, the water level is not used for high lift pump control.

D.3 DISINFECTION PRACTICES

Chlorine gas is used for pre- and postchlorination at the plant. There are three chlorination systems at the plant, one for prechlorination of the pier pump discharge, one for prechlorination of the low lift pump discharge, and one for postchlorination of filtered water. The prechlorination system for the pier pump consists of a Wallace and Tiernan V-notch chlorinator fed by a single gas cylinder. The other two systems consist of Wallace and Tiernan V-notch chlorinators with dual gas cylinders equipped with automatic changeover. All three chlorination systems are interchangeable by means of valving on the chlorine feed piping.

Dosage for pre-chlorinators is set manually. Dosage is selected to maintain a slight free residual in the filtered water. Post-chlorination dosage is also set manually, selected to maintain a total

chlorine residual of 0.3 to 0.4 mg/L in the plant effluent. The points of chlorine application are noted schematically on Figure C.4 and are listed in Section C.4.2.

The weight of chlorine used is obtained from the chlorine scales. Dosage is calculated based on the weight of chlorine used and the total treated water flow.

D.4 OPERATION OF SPECIFIC COMPONENTS

D.4.1 INTAKE

As previously described, the plant is served by two intakes, the gravity flow intake and the submersible pier pump intake.

There are no problems with the pier pump intake. Since the intake is only used during the summer, the pump has to be installed at the beginning of each operating season.

No special operating procedures apply to the gravity intake. The intake can be isolated by closing a valve on the inlet pipe in the raw water valve.

Problems, however, are encountered as a result of the location and shallow depth of the gravity intake. It is reported that, when weather conditions are conducive to the formation of frazil ice, the intake must be flushed up to seven times during the night. The shallow depth of the intake also results in rapid variations in raw water turbidity, created by changing wind direction, currents and other factors. Adjacent to the intake to the east is the Forty Mile Creek which discharges to the lake, and raw water quality is adversely affected by the stream during periods of heavy surface runoff. In addition, backwash water and settled sludge from the water treatment plant is discharged to the lake without treatment, not far from the intake. The presence of a sewage pumping station immediately west of the plant could also affect raw water quality due to occasional wet weather overflows.

D.4.2 SCREENING

Photograph 3 illustrates the type of screen that is being used in the Grimsby plant. It will be noticed that screens must be manually removed and washed on the outside of the Screen House. There are no facilities for the collection and disposal of the wash water and the removed screenings.

D.4.3 LOW LIFT PUMPS

The low lift pumps are started and stopped manually from individual push-button loading stations. No problems were reported, except that the station is limited in flexibility with regard to pump utilization. Pump 2 (13,700 m^3/d) is the main duty pump (see photograph 8) but is oversized for efficient operation at the average day flow rate. Pump 1 is the only other electric motor driven pump. With a rated capacity of 4,090 m^3/d this pump is now undersized for meeting even minimum day flow rates. Pump 3, at a rated capacity of 5,890 m^3/d, would be more suitable for meeting low flows. Since pump 3 is equipped only with a gasoline engine drive, it is not used very often.

D.4.4 RAPID MIXING AND FLOCCULATION

There are no formal rapid mixing facilities at the plant. Blending of chemicals with the process flow is achieved hydraulically within the piping systems.

The flocculators are manually started and stopped from a local push-button loading station. The rotational speed of the flocculators, which determines the energy input for mixing, is set by adjusting the vari-drive speed switch.

Flocculators are susceptible to significant down-time since they are driven by a single motor. During the winter ice forms on the open-top, outdoor tanks. This can lead to problems when a sedimentation tank

needs to be drained for sludge removal. Also, the efficiency of flocculation is impaired as a result of the extremely cold water temperatures.

D.4.5 SEDIMENTATION

Sedimentation tanks are gravity flow-through basins. Flow to the basins can be shut off by a plug valve at the inlet channel to the flocculation tanks (photograph 11).

Three weir overflow launders are provided in each tank for decantation of the effluent.

There are no sludge collector mechanisms and tanks have to be cleaned manually by water spray four times per year. Settled sludge and wash water are discharged to the lake via a drain pipe.

Ice formation on the top of the tanks occurs during the winter. This creates problems at the overflow weirs which are partially protected during the winter with wooden covers. The build up of sludge and ice in the sedimentation tanks will also reduce the effective tank volume and impair settling. Desludging of the basins during the winter is not practical and is therefore only undertaken when absolutely necessary.

D.4.6 FILTERS

The gravity filters in the Filter Building (photograph 2) are operated manually at a predetermined constant rate of filtration. The filter rate is set manually as described in Section D.2 b) and maintained by a mechanical rate controller (Simplex valve on the filter effluent piping).

The pressure filters are operated manually, and no control of filter rate is available, other than by throttling of gate valves on the raw water inlet piping.

Backwash is initiated manually for all filters, based on either the length of time they have been in operation, in-plant turbidity testing of filtered water, or head loss. No alarms or automatic control are provided for filter backwashing. According to operating staff, the filters in use are backwashed once per day for a 15 minute period when the raw water turbidity is high. The gravity filters have the capacity to operate for longer than 24 hours. However, in winter, operating staff backwash each gravity filter once during the day. The practice is necessary because frazil ice forms frequently over the intake during the night, requiring backflushing of the intake several times. If the gravity filters are backwashed at the same time as the intake is back-flushed, there is a risk that production of treated water would not be able to meet demand. The result is that the gravity filters are back-washed more often than necessary.

The filters are returned to service manually when in the opinion of the operator, the filters have been sufficiently backwashed. It is common practice to open the effluent valve slowly over two to three minutes.

D.4.7 CLEAR WELL

There are two clear water wells, clear well 2 below the gravity filters with a capacity of 355 m^3, and clear well 1 with a capacity of 480 m^3 below the pressure filters in the Pumping Station.

Clear well 2 provides the backwash water for the gravity filters and discharges through a 400 m diameter pipe to clear well 1. A manually operated shut-off valve is provided on the discharge header.

Clear well 1 provides detention time for postchlorination and serves as wet well for the high lift pumps.

D.4.8 HIGH LIFT PUMPS

High lift pumps are operated manually from the local pushbutton loading stations. Pumps are selected on the basis of system demand which is inferred by the pressure in the discharge main.

D.5 CHEMICALS

D.5.1 CONTROL OF CHEMICAL DOSAGES

a) Coagulant

Until late January 1986, liquid alum was used as the coagulant at the Grimsby plant. In an attempt to improve treated water quality and reduce operating costs, experimentation with polyaluminum chloride (PACl) was commenced. The plant has been operating using polyaluminum chloride as the coagulant since January 27, 1986.

Polyaluminum chloride (or alum) is stored in a PVC lined, wood stave tank and transferred to a smaller day tank as necessary. Two chemical dosage pumps are available for polyaluminum chloride (or alum) feed, a Wallance and Tiernan type A745 diaphragm pump, and a BIF model 1210-04 pump. The smaller Wallace and Tiernan pump is used as the duty pump.

The feed rate of each pump is set by manually adjusting the speed and stroke length of the pump. No flow-proportional control of the pumps is available. The pumps have not been calibrated for more than 10 years. The operator checks the amount of coagulant used according to the calibration graph against the amount withdrawn from the day tank. PACl is applied at full commercial strength of 33.8 percent.

The operator relies on past trends in selecting an appropriate coagulant dosage. In the past, it has been found that jar test results when used for coagulant control resulted in inadequate treatment. Since total water flow is not metered at the plant, dosage is set approximately, based on treated water flows.

Polyaluminum chloride dosage is calculated by plant staff at every shift using coagulant consumption and total treated water flow. No adjustment of the treated water flow is made to account for in-plant storage (835 m^3 max.). The calculation is outlined as follows:

- Litres of polyaluminum chloride used x 407 = grams of polyaluminum chloride

- $\frac{\text{Grams of polyaluminum chloride}}{m^3 \text{ treated water}}$ = mg/L polyaluminum chloride dosage

The factor 407 represents the weight of polyaluminum chloride in grams per litre of solution. The polyaluminum chloride solution is supplied at a concentration of 33.8% (S.G. = 1.204).

Dry alum is used as a standby coagulant. The operator adds a weighed portion of dry alum to a Wallace and Tiernan unit which mixes alum slurry. Dosage is calculated as the weight of alum used divided by the total treated water flow per shift. A second BIF model 1210-4 pump is available to feed alum slurry.

b) Powdered Activated Carbon

Powdered activated carbon of 400 mesh size is used to control taste and odours. If the operator on duty detects odour (by simply sniffing a sample of the water), dry carbon feed is initiated. A weighed amount of dry carbon is added to the BIF screw type feeder situated over the raw water wet well. The operator sets the dosage at approximately 1 mg/L, based on treated water flow, and a more accurate estimation of dosage is calculated later, based on weight of carbon used and total treated water flow.

Carbon feed is stopped when, in the operator's opinion, odour has dissipated. To test for the dissipation of odour, a raw water sample is drawn from the sample tap, heated and smelled by the operator.

c) Chlorine

As described in Section D.3, chlorine gas in solution form is used for disinfection. Basically, the water flowing through the plant is prechlorinated for purposes of disinfection and slime control, and is

postchlorinated for assuring complete disinfection and to maintain a chlorine residual in the water distributed for consumption.

The chlorine dosage is calculated daily based on the weight of chlorine used for each service, obtained from the chlorine scales, and the total treated water flow.

D.6 SAMPLING AND DATA COLLECTION

D.6.1 PLANT RECORDS

The plant operator monitors operations and maintains the Daily Record. An example of the Daily Record is included in Appendix A of this report.

Results of chemical and biological analyses carried out at the Ministry of the Environment laboratories are tabulated on summary tables at the engineering office of the Regional Municipality of Niagara.

Information, documented for the three-year operating period for this optimization study, is presented in Appendix C, Tables 1.0 through 7.0 inclusive.

A monthly summary of treated water flows for the last three consecutive years is presented in Table 1.0. This table tabulates monthly daily averages, as well as daily maximum and minimum flows in ML/d.

Daily treated water flows are tabulated in Table 1.1. Separate tables are provided for each year of the three-year record. Flow data presented include monthly daily averages, and daily minimums and maximums. Treated water represents the total daily amount of water pumped into the distribution system.

A particulate removal profile for the plant is presented in Tables 2.0 and 2.1 inclusively. Table 2.1 presents average daily values of turbidity for raw, settled, and treated water as well as average daily

coagulant dosages, and raw water temperature. Table 2.0 presents a yearly summary of maximum, minimum, and average values for the parameters given in Table 2.1 and presents the average monthly raw and treated water pH.

The practice of disinfection is covered by Table 3.0, 3.1, and 3.2. Monthly summaries for 1984 to 1986 are given in Table 3.0 and 3.1. These tables present monthly average values for prechlorination and postchlorination dosages, as well as monthly average, maximum and minimum values for the treated water.

A monthly summary of average, maximum and minimum values for carbon for the three year record is given in Table 4.0. Daily carbon dosages for taste and odour control are given in Table 4.1 for 1984 to 1986.

A record of the general chemistry and bacterial water quality is given in Table 5.0. Tests are carried out at the Ministry of Environment laboratories in Toronto and Welland, Ontario, and include:

- general chemical parameters and iron
- bacteria - total coliform, total coliform background, fecal coliform and standard plate count.

A three-year summary of raw and treated water quality is presented in Table 5.1. This table includes all the parameters of Table 5.0 but tabulates yearly average, maximum and minimum values.

Algae analyses were not performed on the Grimsby raw water but 3 to 5 samples per month were analysed for chlorophyll a and chlorophyll b at the Ministry of the Environment laboratory in Toronto. Results of these analyses are presented in Table 6.0.

Monthly summaries of the bacteriological test results for 1984 to 1986 are presented in Tables 7.0 and 7.1.

D.6.2 PROCESS AND QUALITY CONTROL

The plant operator is responsible for maintaining the Daily Record. Data are recorded at various times during the 24-hour day (see Appendix A) and include information on flows, chemical treatment and quality control testing and others. Specific entries of the above form include the following:

a) Flows

- low and high lift pump operation including elapsed time running hours

- flow meter readings - treated water, backwash water, raw water pier pump.

b) Filter Operation

- time each filter is in service, pressure filters 1, 2 and 3, and gravity filters 4 and 5

- filter backwash operations.

c) Chemical Treatment

- consumption for each chemical applied in litres or kg

- dosage for each chemical applied, based on actual consumption and feeder setting

- chemical feeder settings, recorded hourly.

d) Quality Control Testing

The following analyses are carried out at the water treatment plant:

- turbidity	six times per day using a Hach, Model 2100A, bench-top turbidity meter for (raw, settled, filtered water effluent and final plant effluent). The low scale on the meter has a range of 0 to 0.2 NTU.
- odour	several times per day (observation only)
- temperature:	daily, raw water
- chlorine residual	six times per day using a Wallace & Tiernan series A-790 titrator (free Cl_2 residual on filtered effluent and free Cl_2 residual on final effluent)
- jar tests:	as the operator deems necessary to assist in estimating coagulant dosage, using a Phipps and Bird jar tester.

D.6.3 WATER QUALITY EXAMINATION

Water quality analyses for various chemical, biological and bacteriological parameters are carried out routinely at the Ministry of the Environment laboratories. Parameters that have been analyzed for and the frequency of the analyses are as follows:

- bacteriological analyses	. at MOE lab . raw and treated water sampled once per week.
- general chemistry	. once per month at MOE lab including: - test series G + WC51S and FEUT on raw water: conductivity, hardness, alkalinity, pH, chloride, turbidity, colour, and iron

- test series G + WC52 + FEUT on treated water: same parameters as above for raw water
- tests series G + LTGLIM on raw water: chlorophyll a and chlorophyll b, 3 to 5 samples per month tested during 1984 and 1985.

D.6.4 LABORATORY EQUIPMENT

The plant has a laboratory counter in the high lift pump room (photograph 19). The basic lab equipment available includes:

- 1 Hach, Model 2100A, bench-top turbidity meter
- 1 Wallace and Tiernan Series A-790 titrator
- 1 Phipps and Bird Jar Test Apparatus

D.7 PROCESS AUTOMATION

There is no automated equipment at the plant except perhaps for the Wallace and Tiernan chlorinators which include flow-proportional controllers. All pumping and process equipment is oeprated on a manual basis. Gravity filters maintain constant rate by mechanically-operated filter rate control valves.

D.8 DAILY OPERATOR DUTIES

The Superintendent, Area 3 (Water) is responsible for the treatment process and all activities that take place at the plant. He holds a supervisory and staff management position and deals with matters relating to the public. Plant maintenance is the responsibility of the Foreman, Area 3 (Water).

Plant operators are responsible for the day-to-day running of the plant. A partial list of the major duties of the operators includes such activities as:

- keeping records of process operations, chemical treatment and quality control testing,
- checking operation of all equipment and responding to problems when they arise,
- initiating filter backwashing and observing operations,
- responding to and recording treatment upsets, equipment outages, unusual events such as cases of vandalism,
- carrying out water quality control tests and collecting water samples for analysis by outside laboratory,
- setting feed rates of liquid chemical metering equipment and chlorinators,
- receiving chemical deliveries and ensuring adequacy of supplies,
- exercising standby mechanical equipment,
- responding to alarm conditions.

In addition to the physical tasks listed above, operators must stay in constant communication with the Regional Superintendent and Foreman.

SECTION E

PLANT PERFORMANCE

SECTION E - PLANT PERFORMANCE

E.1 GENERAL OVERVIEW

Plant operations and performance at the Grimsby Water Treatment Plant were discussed with the Region of Niagara Superintendent, Area 3 (Water), during the site visit on December 16, 1986.

Lake Ontario water is processed by conventional treatment to produce potable drinking water. During the summer, production flows in excess of the capacity of the conventional gravity flow filtration plant are treated by direct filtration in pressure filters. Alum was normally used as the coagulant chemical but during 1986 polyaluminum chloride was used on a trial basis.

Raw water in the vicinity of the intake is subject to wide variations in turbidity during the year. Variations are seasonal and are influenced by the discharge form the nearby Forty Mile Creek.

The operating record reviewed (1984 to 1986) revealed that overall, the treatment process performed well at the hydraulic loadings and solids levels experienced during the study period. On a monthly average basis, filtered water effluent turbidities ranged from 0.10 to 0.56 NTU regardless of which coagulant was used. On a daily basis, higher turbidity values in excess of 1.0 NTU were experienced on several occasions as a result of rapidly fluctuating levels of raw water turbidities. Poor effluent quality was normally contained to one day except for the period of December 27 to 29, 1986, when the effluent turbidity was consistently above 1.0 NTU.

The alum coagulant during 1984 and 1985 was found to work well but higher than normal dosages were required for effective treatment. With polyaluminum chloride, on the other hand, problems were experienced during periods of high raw water turbidities and cold water; hence the use of this coagulant chemical was discontinued in the spring of 1987 in favour of alum.

Unpleasant taste and odours are encountered during the summer months, and on occasions during other times of the year. These odours are effectively controlled by powdered activated carbon treatment.

Disinfection of the raw water is achieved by prechlorination and post-chlorination. A good record was established for 1984 to 1986; none of the test samples contained fecal coliform organisms and only one sample in 1986 and two in 1985 tested positive for total coliform.

In summary, therefore, it was concluded that no significant water quality problems exist, either at the plant or in the distribution system. The objectives for water treatment are being achieved in spite of the occurrence of adverse raw water quality, the age of the treatment plant, and operational problems encountered during the wirter as a result of frazil ice in the intake and ice build-up on the surface of the outdoor flocculation and sedimentation tanks. During the winter a quantity problem exists due to partial blockage of the intake by frazil ice.

E.2 TURBIDITY

E.2.1 EVALUATION OF PARTICULATE REMOVAL EFFICIENCY

a) Raw Water Quality

Operating records for particulate removal at the Grimsby Water Treatment Plant are presented in Tables 2.0 and 2.1 of Appendix C. Table 2.0 presents a monthly summary of the average, maximum and minimum raw and treated water turbidity values for 1984 and 1986. In addition, corresponding values are tabulated for i) primary coagulant, ii) raw water temperature and, iii) raw and treated water pH. Average daily values for raw, settled and treated water turbidities, as well as raw water temperature, are recorded in Table 2.1.

In this plant, particulate matter is removed from the raw water by sedimentation and filtration. Polyaluminum chloride (PACl) was used as

the coagulant and is added to the inlet of the raw water suction piping at the raw water well for the main intake or at the pier pump. No. direct mechanical mixing is provided prior to flocculation. Polyaluminum chloride replaced liquid alum as the coagulant on January 27, 1986.

In early 1987, the coagulant application point was changed from the raw water well to the low lift pump discharge header in the Pumping Station.

Lake Ontario water in the region of the Grimsby plant intake, is subject to wide variations in turbidity during the year (Figure E.1). Variations are seasonal and are influenced by i) the shallow and near shore intake location, and ii) the proximity of the intake to the outlet of the Forty Mile Creek. The highest levels of turbidity occur during spring storms when sediment loadings in the creek are high. The highest instantaneous raw water turbidity recorded during the study period on March 29, 1985 was 280 NTU. In addition to high levels, operating staff have reported that turbidity can fluctuate by up to 200 NTU in a 15 minute period which can lead to operational problems at the treatment plant.

Figure E.1 presents monthly raw water turbidity data for 1986 to 1984. Graphs are shown for:

- the monthly average day
- the maximum average day of the month
- the minimum average day of the month.

From the figure, it will be evident that the greatest variation in turbidity occurs during the fall to spring period between November and April. During this period maximum day averages range from 15 to 144.8 NTU. As for instantaneous maximum turbidity values, the highest maximum day averages also occur during the spring in February, March and April. The maximum day values recorded for this period are:

139.3 NTU - February 1984, 125.8 NTU - April 1984, 116.2 NTU - March 1985, 144.8 NTU - April 1985, and 69.5 NTU - April 1986. During the summer periods from May to October, maximum day averages for the month vary form 2.5 to 68.0 NTU, while monthly average day values vary from 1.7 to 12.7 NTU.

An analysis of the frequency of occurrence of the monthly average day turbidity levels is given in Table E.1 following. This table was derived from the graph of Figure E.2 and illustrates that the average monthly raw water turbidity is less than 25 NTU for ninety percent of the time, and less than 8 NTU for fifty percent of the time.

Table E.2 presents information on the high raw water turbidity events. The record shows that periods of high turbidity can last for as long as eight day (Mar. 29 - Apr. 5, 1985). Such periods of high turbidity fortunately coincide with lower water demand as illustrated in Figure E.3 which tends to lessen the impact of high solids loadings on settling performance.

b) Particulate Removal

Particulate removal occurs in two unit processes in the plant, namely the sedimentation tanks and the filters. Until January 26, 1986, liquid alum, or dry alum on an emergency basis, was added to the raw water as the coagulant. On January 27, 1986, the coagulant was changed from alum to polyaluminum Chloride. Coagulant feed rates were adjusted manually by the operators in accordance with changes in raw water turbidity, temperature, and the level of the filtered effluent turbidity.

An alum or polyaluminum chloride (PACl) dosage guide was not available at the plant; apparently jar tests are carried out as required. Coagulant dosages are set based on experience and treated water effluent quality.

Actual alum dosages applied during the study period are shown graphically as follows:

TABLE E.1

RAW WATER QUALITY - TURBIDITY AND FREQUENCY

1984 to 1986

Turbidity [1] NTU	Frequency per cent time	Total Time Jan. 1984 - Dec. 1986, d
Under 5	31	329
5-10	30	329
10-20	12	131
20-30	21	230
Over 30	6	66
	100	1095

[1] Average monthly raw water turbidity

TABLE E.2

HIGH RAW WATER TURBIDITY EVENTS

1984 - 1986

1986	Turbidity (NTU)	1985	Turbidity (NTU)	1984	Turbidity (NTU)
		Jan.1	81.50	Feb.14	82.50
Apr.5	69.50	Jan.2	78.30	Feb.15	37.60
Apr.6	40.00	Jan.3	64.70	Feb.16	36.17
Apr.17	65.70	Jan.4	53.70		
		Jan.5	61.50	Feb.28	76.16
Dec.24	24.50	Jan.6	18.30	Feb.29	139.30
Dec.25	59.70	Jan.7	60.30	Mar.1	44.80
Dec.26	39.20	Jan.8	72.70		
Dec.27	37.27	Mar.4	83.80	Mar.28	43.00
Dec.28	35.80	Mar.5	116.20	Mar.29	66.80
Dec.29	52.00	Mar.6	76.50	Mar.30	46.80
		Mar.7	62.50		
				Apr.5	125.80
		Mar.29	88.00	Apr.6	25.80
		Mar.30	34.20	Apr.7	51.50
		Mar.31	96.00	Apr.8	35.80
		Apr.1	144.80	Apr.9	38.50
		Apr.2	126.50	Apr.10	43.80
		Apr.3	73.30	Apr.11	31.50
		Apr.4	50.60	Apr.12	35.83
		Apr.5	62.50	Apr.13	31.00
				Apr.14	40.33
		Nov.4	56.50	Apr.15	40.67
		Nov.5	82.30	Apr.16	45.20
		Nov.6	46.50		
		Nov.7	46.30	Dec.21	32.66
				Dec.22	62.00
		Nov.17	56.00	Dec.23	42.50
		Nov.18	51.00		
		Nov.28	58.50		
		Nov.29	38.80		

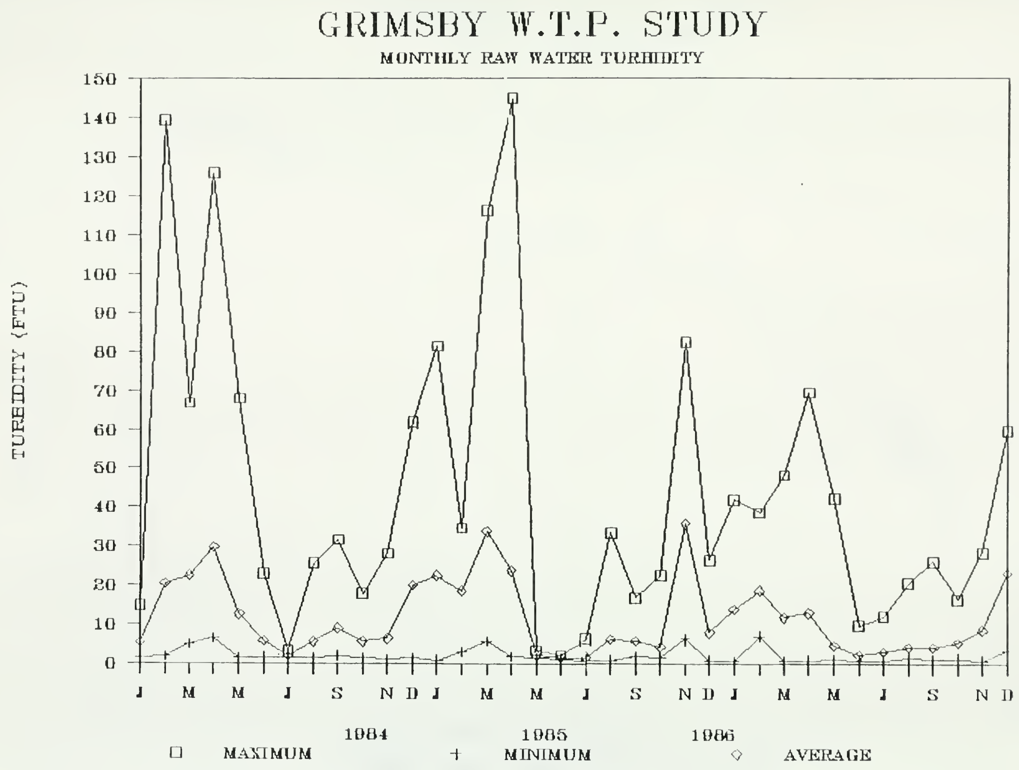

GRIMSBY W.T.P. STUDY
MONTHLY RAW WATER TURBIDITY
TURBIDITY (FTU)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
J M M J S N D J M M J S N D J M M J S N D
1984
1985
1986
MAXIMUM
MINIMUM
AVERAGE

Figure E.1

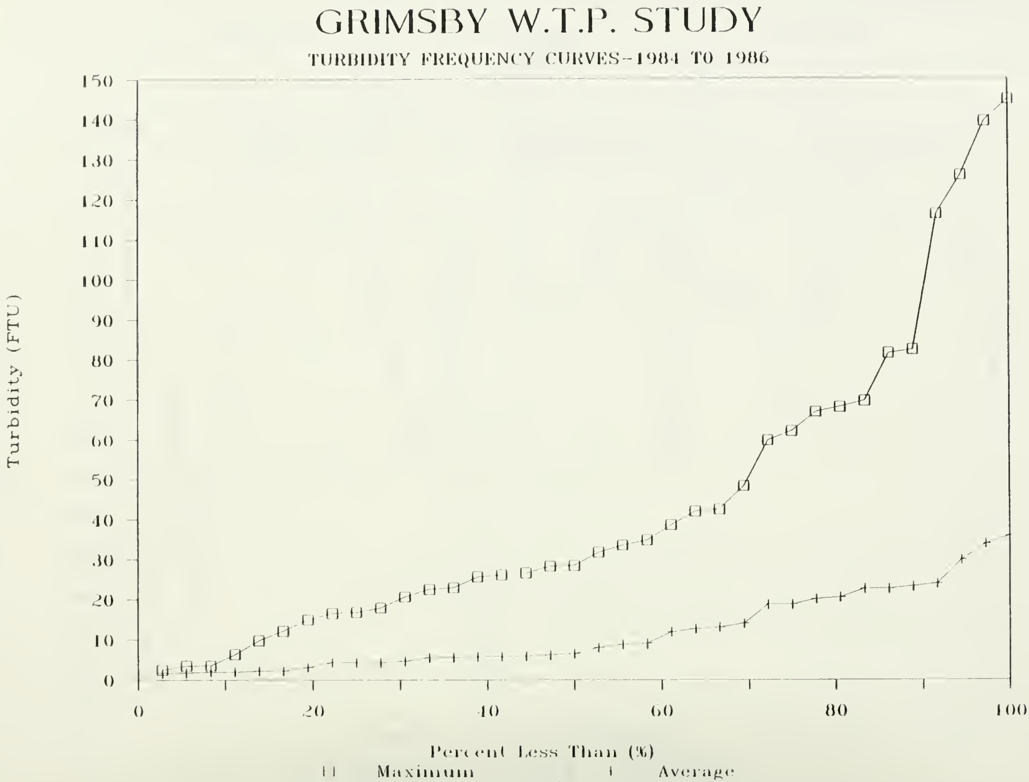

GRIMSBY W.T.P. STUDY
TURBIDITY FREQUENCY CURVES–1984 TO 1986
Turbidity (FTU)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Less Than (%)
Maximum
Average

Figure E.2

GRIMSBY W.T.P. STUDY

MONTHLY AVERAGE FLOWS

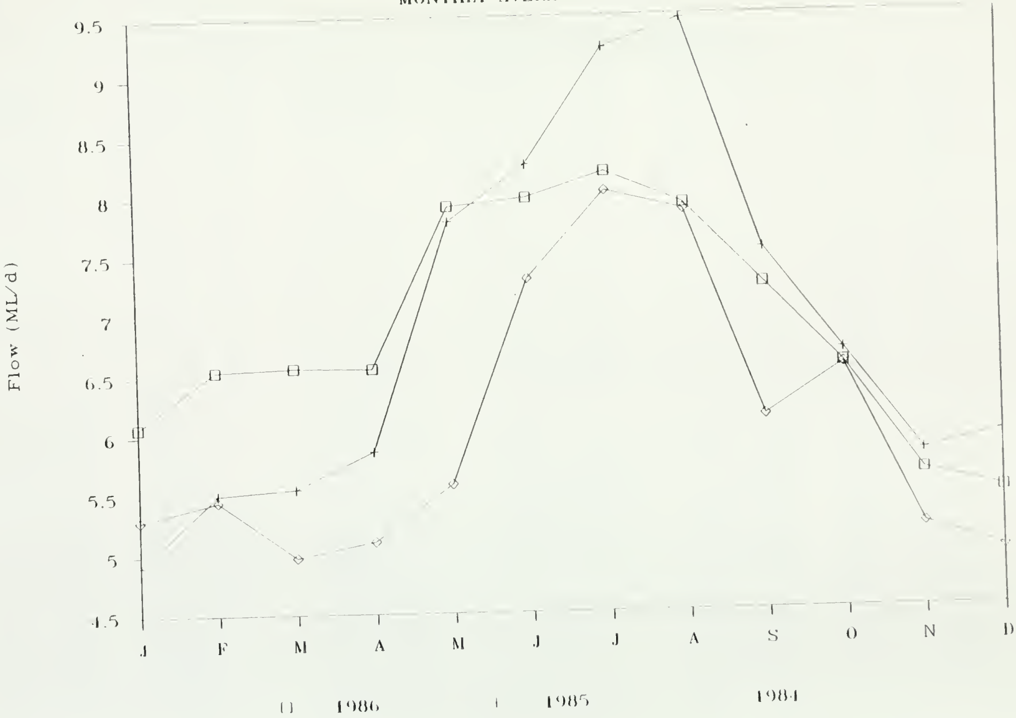


Figure E.3

- Figure E.4 - Alum Dosage Applied vs. Average Day Raw Water Turbidity for January 1985.

- Figure E.5 - Alum Dosage Applied vs. 7-Day Average Raw Water Turbidity for May, June and July 1985.

In addition to the above, maximum day turbidity values versus alum dosages applied were examined for the years 1984 and 1985. The operational record is shown in Table E.3. A summary at the end of the table presents average values for the record as well as the range of low and high values encountered.

Operating data on PACl are presented in Figures E.6 and E.7. The former figure presents a dosage graph in terms of 7-day averages for May, June and July 1986, while the graph in Figure E.7 presents the relation of monthly maximum values for the two parameters being considered. PACl dosages applied with turbidities in excess of about 40 NTU are summarized in Table E.4.

Performance curves for the sedimentation basins and filters are plotted in Figure E.8. These curves represent monthly average day raw water turbidities versus settled water and filtered water turbidities. Table E.5 presents a summary of turbidity removal and coagulant dosages in terms of monthly average day values.

In reference to Figure E.8 and Table E.5 it is evident that:

- Settling basins perform well at the higher raw water turbidity values for both alum and PACl coagulants, efficiencies of removal being over 85 percent in most cases.

- At low raw water turbidities, less than 10 NTU, settling basin performance is much less than at higher turbidities. But this lower performance does not affect filter operation since total solids carried over to the filters are still less than one-half those at high raw water turbidities.

- Filter performance (gravity filters) during the summer period (May to October), and during November when raw water turbidity remains at low levels, is quite good with filtered water effluent turbidities falling in the range of 0.10 to 0.20 NTU. This holds true for 1984 and 1985 when alum was used as the coagulant, as well as for 1986 when polyaluminum chloride was applied.

- During the fall to spring period (November to April) when raw water turbidities fluctuate rapidly with storm events and reach high levels, filter effluent quality deteriorates from that observed during the summer period. With alum as the coagulant, the range in monthly average day filtered water effluent turbidity is from 0.15 to 0.40 NTU (1984 and 1985); while with PACl as the coagulant (1986) the range is from 0.18 to 0.56 NTU.

- On a monthly average basis, the turbidity in the filtered water over the study period ranged from 0.10 to 0.56 NTU. The yearly average values for 1984, 1985 and 1986 were 0.22 NTU, 0.19 NTU and 0.23 NTU respectively.

- Based on a consideration of monthly and yearly averages, particulate removal by the treatment plant is good and meets the current drinking water guideline of 1.0 NTU.

Overall water quality goals are being achieved in spite of the age of the treatment facility and the lack of mechanical coagulation equipment. On a day-to-day basis, operating problems during the periods of adverse water quality are more evident and will be examined in the following evaluation.

Hydraulic Loadings of Process Units

Monthly average, maximum and minimum day flows to the treatment plant during the study period are tabulated in Table 1.0 of Appendix C. Table E.5 summarizes monthly average flows and presents values for the minimum and maximum month of the year. From these records it is evident that the actual flows to the treatment plant ranged from a minimum

TABLE E.3

SUMMARY OF HIGH RAW WATER TURBIDITIES AND

APPLIED ALUM DOSAGES - 1984 AND 1985

Month	Raw Water Turbidity, NTU	Alum Dosage, mg/L
Feb. 1984	139.3	91.6
Mar.	66.8	85.3
Apr.	125.8	106.1
May	68.0	65.4
Dec.	62.0	90.5
Jan. 1985	81.5	87.0
Mar.	116.2	76.0
Apr.	144.8	72.4
Nov.	82.3	85.3
Average	99.3	84
Range	62.0-144.8	65.4-106.1

TABLE E.4

SUMMARY OF HIGH RAW WATER TURBIDITIES AND
APPLIED PACl DOSAGES - 1986

Month	Raw Water Turbidity, NTU	PACl Dosage, mg/L
Feb. 1986	38.6	13.4
Mar.	48.3	26.1
Apr.	69.5	14.9
May	42.4	23.7
Dec.	59.7	31.9
Average	51.7	22
Range	38.6-69.5	13.4-31.9

TABLE E.5

SUMMARY OF TURBIDITY REMOVAL AND COAGULANT DOSAGES

	1986					1985					1984				
Month	Flow[1] (ML/d)	Raw (NTU)	Settled (NTU)	Treated (NTU)	PolyAlCl (mg/L)	Flow[1] (ML/d)	Raw (NTU)	Settled (NTU)	Treated (NTU)	Alum (mg/L)	Flow[1] (ML/d)	Raw (NTU)	Settled (NTU)	Treated (NTU)	Alum (mg/L)
J	6.073	14.10	2.33	0.26		4.915	22.70	2.05	0.27	48.76	5.293	5.52	2.07	0.22	28.90
F	6.542	18.80	4.84	0.18	9.86	5.504	18.80	2.68	0.36	52.12	5.448	20.60	2.80	0.28	45.11
M	6.564	12.00	4.15	0.21	7.92	5.547	33.90	3.29	0.40	51.12	4.976	22.70	2.48	0.39	62.05
A	6.552	13.10	4.20	0.53	6.73	5.860	23.90	2.32	0.15	38.84	5.104	29.80	2.54	0.33	64.80
M	7.914	4.75	2.08	0.30	4.85	7.785	2.30	1.22	0.13	20.64	5.577	12.70	1.68	0.18	35.70
J	7.977	2.25	1.52	0.15	5.03	8.257	1.69	1.17	0.13	18.64	7.294	5.90	1.62	0.19	27.98
J	8.188	3.16	1.95	0.13	6.52	9.227	1.78	1.13	0.14	18.07	8.026	2.00	1.28	0.22	24.77
A	7.916	4.39	2.43	0.11	6.36	9.461	6.21	1.40	0.17	24.12	7.860	5.80	1.03	0.16	32.13
S	7.236	4.37	2.00	0.10	5.92	7.527	5.97	1.07	0.12	23.57	6.117	9.10	0.97	0.13	36.56
O	6.554	5.58	2.36	0.14	8.24	6.665	4.35	1.05	0.10	23.29	6.540	5.79	1.10	0.12	31.19
N	5.641	8.83	2.60	0.14	9.09	5.805	35.80	2.34	0.18	51.93	5.192	6.60	1.12	0.12	31.23
D	5.478	23.30		0.56	12.37	5.956	8.10	1.87	0.12	27.24	4.980	20.10	1.85	0.25	52.90
Average	6.886	9.55	2.77	0.23	7.54	6.876	13.79	1.80	0.19	33.20	6.034	12.22	1.71	0.22	39.44
Minimum	5.478	2.25	1.52	0.10	4.85	4.915	1.69	1.05	0.10	18.07	4.976	2.00	0.97	0.12	24.77
Maximum	8.188	23.30	4.84	0.56	12.37	9.461	35.80	3.29	0.40	52.12	8.026	29.80	2.80	0.39	64.80

(1) Treated water flow.

TABLE E.6

GRIMSBY W.T.P. - HYDRAULIC LOADINGS OF PROCESS UNITS

Process Unit	Unit Loading Rates			
	1986 Plant Flows, ML/d			
	Yearly Avr. (6.886)	Max. Day (13.406)	Min. Day (4.180)	Design Flow, ML/d (5) (13.600)
Rapid Mixing(1)				
Flocculation				
Detention Time, min.	47	24	78	24
G Value, s^{-1}(2)	5.1	5.1	5.1	5.1
Gt Product	14,500	7,460	23,900	7,350
Sedimentation				
Detention Time, h	3.2	1.6	5.2	1.6
Overflow Rate, $m^3/m^2.h$	0.96	1.88	0.59	1.90
Gravity Filters				
Filter Rate, $m^3/m^2.h$(3)	4.74	9.23	2.88	9.37
Pressure Filters(4)				
Filter Rate, $m^3/m^2.h$				4.88(6)

(1) Hydraulically in low lift pumps and raw water piping.

(2) At Vari-Drive speed setting of 2.

(3) During backwashing filter rate increases by 100%.

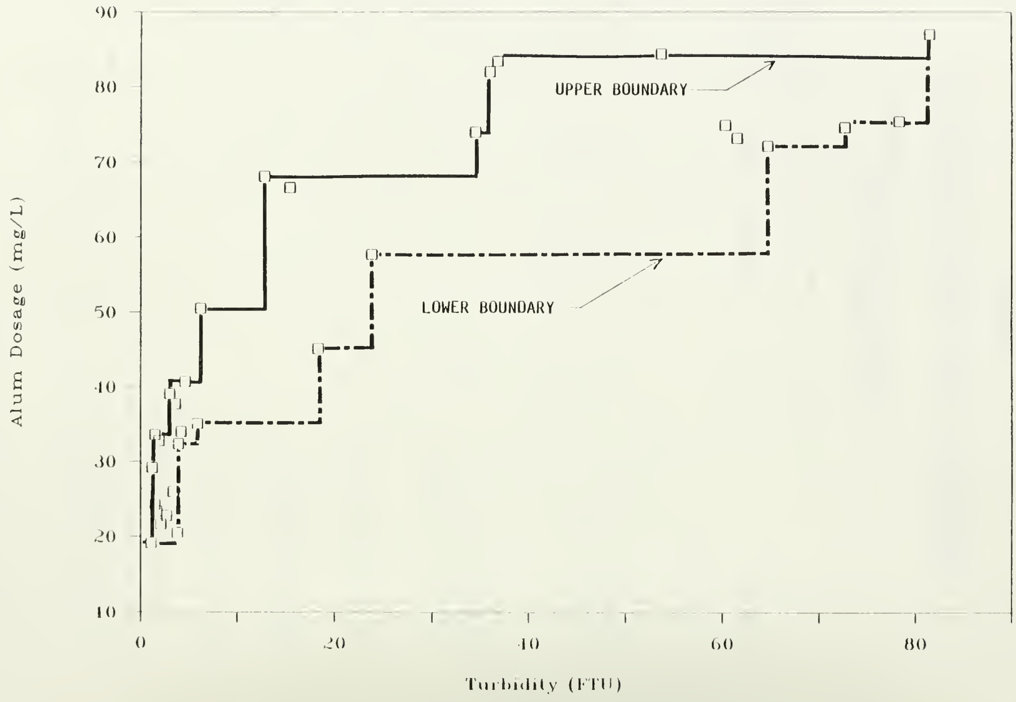
(4) Only used during peak summer demand - time in operation not available.

(5) Current rated capacity of conventional plant.

(6) At design flow rate of 4,900 m^3/d.

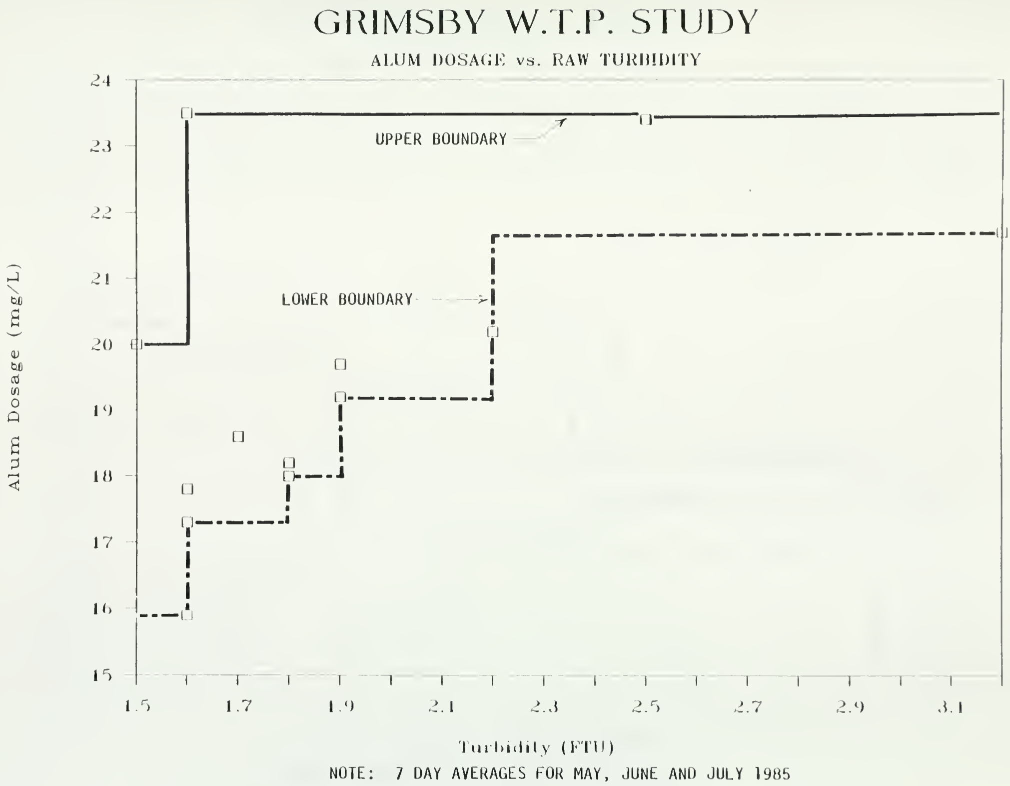
GRIMSBY W.T.P. STUDY

ALUM DOSAGE vs. RAW TURBIDITY



NOTE: AVERAGE DAY - JANUARY 1985

Figure E.4



GRIMSBY W.T.P. STUDY
ALUM DOSAGE vs. RAW TURBIDITY
UPPER BOUNDARY
LOWER BOUNDARY
Alum Dosage (mg/L)
24
23
22
21
20
19
18
17
16
15
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
Turbidity (FTU)
NOTE: 7 DAY AVERAGES FOR MAY, JUNE AND JULY 1985

Figure E.5

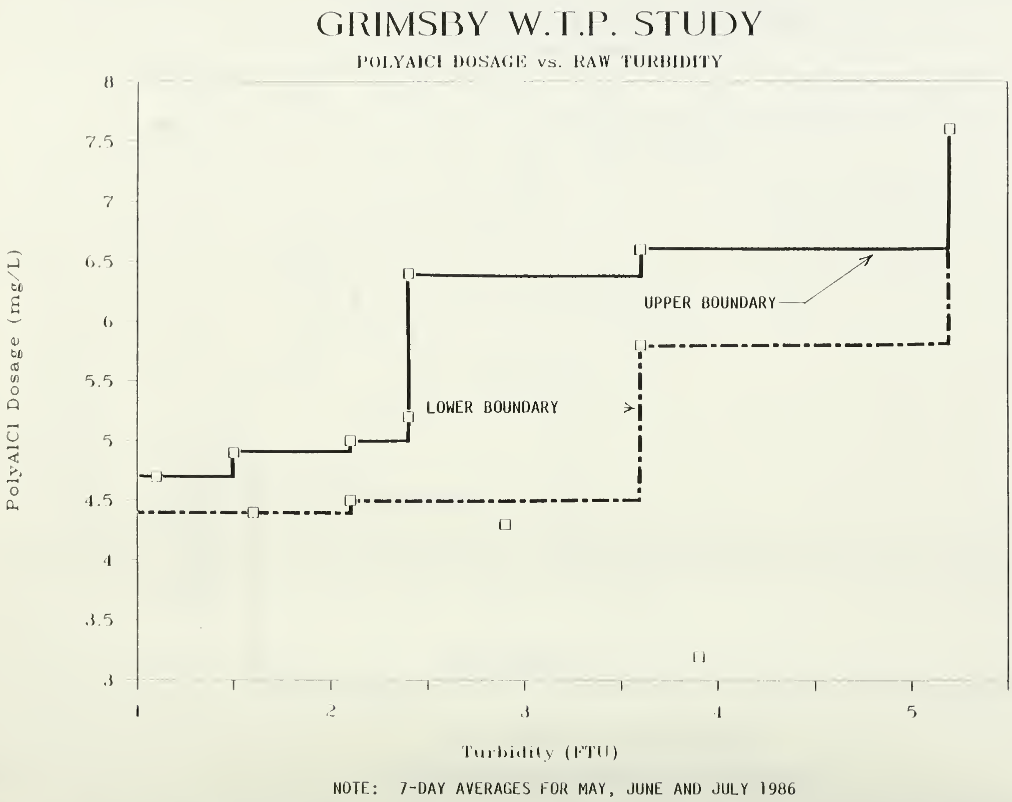
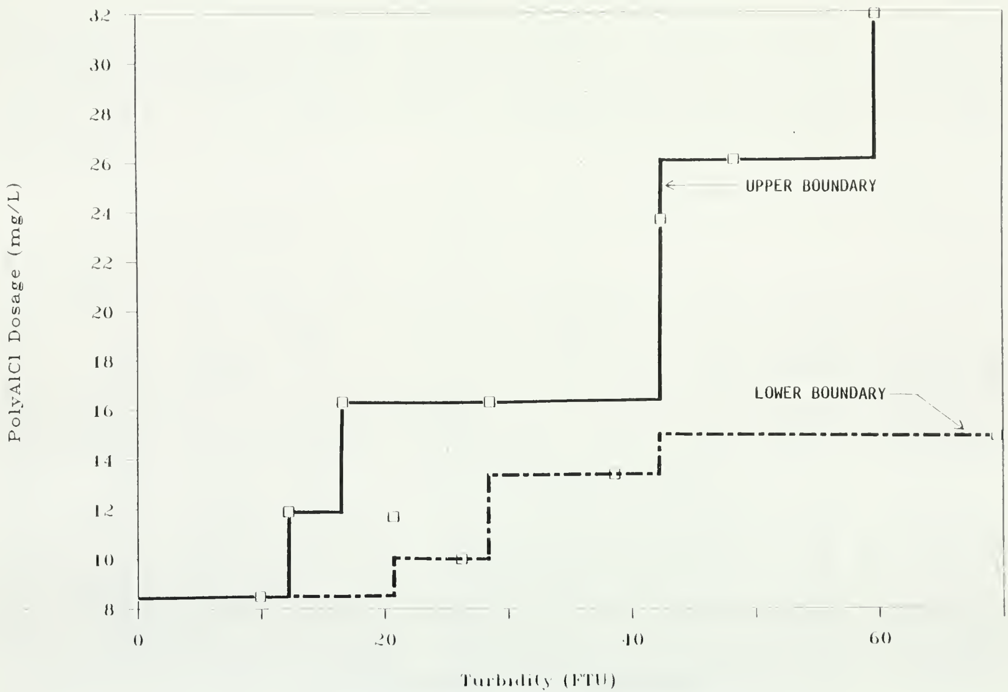

GRIMSBY W.T.P. STUDY
POLYAlCl DOSAGE vs. RAW TURBIDITY
PolyAlCl Dosage (mg/L)
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
1
2
3
4
5
Turbidity (FTU)
UPPER BOUNDARY
LOWER BOUNDARY
NOTE: 7-DAY AVERAGES FOR MAY, JUNE AND JULY 1986

Figure E.6

GRIMSBY W.T.P. STUDY

POLYAICI DOSAGE vs RAW TURBIDITY



NOTE: MONTHLY MAXIMUM DAY TURBIDITY FOR 1986

Figure E.7

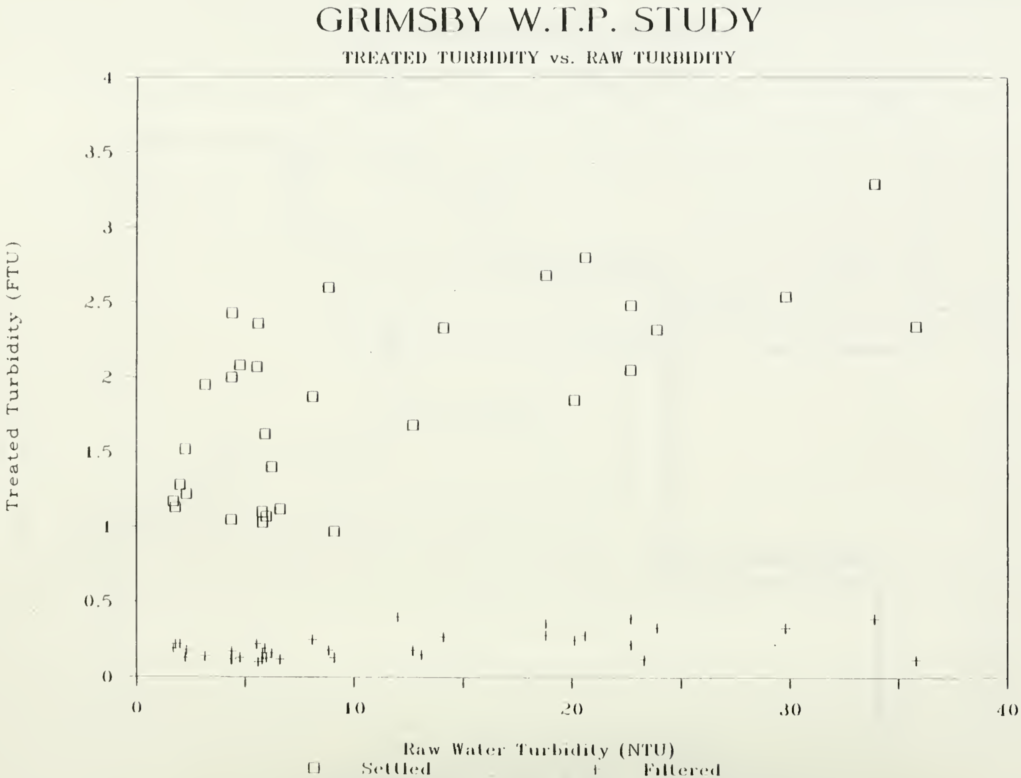

GRIMSBY W.T.P. STUDY
TREATED TURBIDITY vs. RAW TURBIDITY
Treated Turbidity (FTU)
4
3.5
3
2.5
2
1.5
1
0.5
0
10
20
30
40
Raw Water Turbidity (NTU)
Settled
Filtered

Figure E.8

average day of 3.441 ML/d set in January 1985 to a maximum average day of 13.555 ML/d set in July 1985. Yearly average flows were 6.034 ML/d, 6.876 ML/d, and 6.886 ML/d for 1984, 1985 and 1986 respectively. Using 1986 flows, corresponding unit process loading rates have been calculated and are compared with design loadings in Table E.6.

Design loading rates for pre-treatment units of flocculation and sedimentation seem to be on the high side - especially for cold water when floc formation is difficult and settling is impaired. The design filter rate of 9.37 m/h appears to be conservative for dual media filters and is less than the current accepted maximum of 11.7 m/h. However, operating difficulties at high loading rates have been reported over the years, and in view of the fact that there are only two filters, resulting in 100% overload during the backwashing of one filter, it would appear reasonable to down-size the rated plant capacity to about one-half the current rating, or 6,800 m^3/d, which is the design capacity of the original single layer sand filters constructed during the plant expansion in 1957. At 6,800 m^3/d, loading rates for flocculation and sedimentation basins also are more appropriate (see Table E.6 for yearly average flow), and approach generally recommended design values in case of a difficulty to treat water.

Based on the above discussion, it can be concluded that the Grimsby W.T.P. (gravity flow section) is overloaded almost all the time. During 1986 average day water production approached the original design capacity of 6,800 m^3/d during November, December, and January to April; during all other months of the year this capacity was exceeded. This situation will explain the use of the pressure filters with a design capacity of 4,900 m^3/d at a design loading rate of 4.88 m/h. With the additional capacity of the pressure filters, the total plant filtration capacity is 11,700 m^3/d. This capacity however is only available during periods when raw water turbidity is low (May to October) since pressure filters are operated in the direct filtration mode with raw water supplied by the pier pump. In this regard, the pressure filters are valuable and are used primarily to help treat maximum day summer flows. On occasions, when the pier pump is drawing turbid water, or

when the gravity filters appear overloaded, settled water can be pumped back to feed the pressure filters (see Figure C.3).

Plant Performance With High Raw Water Turbidity

Table E.7 presents plant operating data for periods with high raw water turbidity. Data selection was based on:

- high (or above normal) raw water turbidities;
- poor performance of settling basins as evident by high settled water turbidity;
- filtered water effluent turbidity higher than normal and when the drinking water objective of 1.0 NTU was exceeded;
- the use of unusually high alum or PACl coagulant dosages.

By examining the data in Table E.7 for alum coagulation (1984 to January 26, 1986), it will be noticed that:

- Settling basin performance generally was quite good with the exception of March 29, 1985 when the average settled water turbidity for the day was 19.5 NTU.

- Treated water turbidity on the other hand, in spite of low settled water turbidities, generally was on the high side and exceeded the objective of 1.0 NTU many times. A maximum treated water turbidity of 3.4 NTU as recorded for March 29, 1985. When PACl was used as the coagulant, a maximum treated water turbidity of 10.6 NTU was recorded for December 27, 1986.

- The poor filter performance occurred with only moderately high levels of raw water turbidity and flows well below the design capacity of 6,800 m^3/d.

It is suggested that some of the reasons for the poor performance may be attributed to:

- the cold raw water temperature combined with high turbidity which

TABLE E.7

PLANT PERFORMANCE DURING PERIODS OF

HIGH RAW WATER TURBIDITY - 1984 to 1986

Date 1986		Average Day Turbidity, NTU Raw	Settled	Treated	Alum mg/L	PACl mg/L	Flow ML/d
Jan.	19	12.6	2.9	0.24	49.7		5.873
	20	22.6	1.6	0.17	46.6		6.156
	21	21.3	2.9	0.45	47.9		6.094
	22	18.3	3.9	0.47	62		6.030
	23	9.8	2.7	0.28	82.9		6.415
	24	10.4	2.7	0.41	89.9		5.947
	25	22.0	3.8	0.45	48.5		5.884
	26	21.3	4.0	0.51	54.6		5.737
	27	35.7	4.6	0.60	32.3	14.9	6.316
	28	12.9	2.9	0.23		16.2	6.228
Apr.	17	65.7	23.7	9.54		14.9	5.918
	18	10.1	4.3	0.59		11.9	7.304
May	19	30.4	1.2	1.42		3.4	6.545
	20	42.4	10.3	2.50		23.7	6.024
	21	3.0	8.8	0.22		12.6	7.127
Nov.	26	21.0	5.4	0.41		16.0	5.254
	27	27.4	3.4	0.99		8.5	5.481
	28	8.8	6.5	0.10		16.1	5.681
Dec.	27	37.3		10.64		29.5	4.180
	28	35.8		1.02		22.2	6.105
	29	52.0		1.31		21.1	4.985
	30	31.7		0.22		31.9	4.883
	31	37.5		0.11		17.5	6.596
1985							
Jan.	10	36.8	3.1	0.97	83.4		4.050
	11	36.0	4.7	1.60	82.0		4.296
	12	23.8	2.6	0.32	57.7		4.571
	13	12.8	2.0	1.03	68.1		3.746
Feb.	4	83.8	3.3	0.24	59.7		5.992
	5	116.2	5.5	0.31	76.0		5.484
	6	76.5	4.5	0.64	64.0		5.182
	7	62.5	4.9	1.03	65.6		5.644
	8	39.8	3.8	0.61	62.1		5.784
	9	35.2	4.1	0.80	67.3		5.569
	10	35.3	3.8	0.56	65.3		5.305
Mar.	28	18.5	1.9	0.14	43.8		5.325
	29	88.0	19.5	3.4	66.8		4.880
	30	34.2	2.1	0.12	52.5		6.233
Nov.	5	82.3	1.2	0.14	59.4		5.308
	6	46.5	1.5	1.82	61.0		5.631
	7	46.3	1.9	0.17	85.3		5.388
1984							
Feb.	27	8.1	1.5	0.21	41.7		5.796
	28	78.2	2.5	0.27	75.9		4.591
	29	139.3	4.2	0.15	75.0		4.959
Mar.	1	44.8	3.5	1.10	81.0		5.092
	2	14.6	2.1	0.45	64.4		4.796
	3	13.8	2.3	0.43	50.9		4.855
	4	12.7	2.3	0.43	47.8		4.509
Apr.	4	24.5	2.1	0.18	55.5		4.751
	5	125.8	9.5	0.55	83.5		4.619
	6	25.8	3.7	0.63	77.2		4.596
	7	51.5	4.6	0.98	103.1		4.387
	8	35.8	3.3	0.30	89.0		4.696
	9	38.5	4.5	1.97	106.1		5.105
	10	43.8	2.9	0.26	77.4		5.514
	11	31.5	3.1	0.23	75.2		4.869
	12	35.8	3.7	0.37	88.0		4.878

- poor coagulation;
- insufficient flocculation;
- the unusually high alum dosage applied which may be due to the lack of adequate rapid mixing and insufficient flocculation.

It appears that the high alum dosage is required to maintain a low settled water turbidity as well as for maintaining the desired filtered effluent quality. Unfortunately, alum produces a weak floc which will break through the filters as the shearing forces increase with increasing head loss and/or filter rate.

A second problem with the high alum dosages relates to the large voluminous floc that is produced which, if carried over to the filters even in only small quantities, will result in significantly shorter filter runs.

Shortened filter runs require more frequent backwashing which will impact significantly on the net water production capacity of the plant. Plant staff indicated that with poor raw water quality filters are backwashed at least once during a 24-hour period. For a 10-minute backwash and surface rinse, about 250 m^3 of water are required at the design backwash rate for cleaning of one filter. For two filters in a 24-hour period, this amount to 500 m^3/d or about 8.5% of the net amount of water produced on April 17, 1986. Since clear well 2 only has a capacity of 355 m^3, problems may be encountered with the operation of the filters.

During 1986, with polyaluminum chloride as the coagulant, the problem of poor filtered effluent quality experienced during periods when raw water turbidity was high may be attributed to under dosing rather than overdosing. However, overdosing with PACl also occurred but generally only following the correction of an under dose.

c) <u>Treatability Tests</u>

Jar tests were performed on Grimsby W.T.P. raw water taken on April 24, 1987 when raw water turbidity was relatively high (30 to 40 NTU).

These tests were carried out to establish the optimum coagulant dosages for liquid alum and polyaluminum chloride as well as to compare the performance of the two coagulant chemicals in terms of: optimum dosage, time to visibility of first floc, floc appearance, floc size and quantity, settling velocity, and turbidity of filtrate form a laboratory filter paper.

Five jar tests were done in total, two with alum and two with PACl, and one with alum and PACl at previously determined optimum dosages. Test procedures and results obtained are presented in Appendix B. Results for settled water turbidity were plotted in terms of settling velocity distribution curves for each test. Settling velocities measured ranged from 0.465 cm/min. (138 Igpm/sf) to 6.00 cm/min. (1800 Igpm/sf).

For Test 1, the raw water turbidity was 31.1 NTU, the temperature 10°C, and the pH 7.95. Apparent colour was measured at 25 Hazen units. The optimum alum dosage is probably somewhere between 16 and 24 mg/L; however, based on filtered effluent quality, settling performance, and the objective for minimum chemical consumption, 16 mg/L could be considered adequate. The maximum settling velocity measured was 3.33 cm/min. at which rate the settled water turbidity was 3.0 NTU. This settling velocity is equivalent to 2.0 m/h (1000 Igpd/sf). In full-scale design this rate should translate to a maximum value of 1.0 m/h (500 Igpd/sf). The filtrate turbidity of 0.06 NTU is indicative of good coagulation leading to a high quality effluent in full-scale treatment.

For Test 2 raw water quality was similar to that of Test No. 1. Almost identical results were achieved with alum dosages of 14 and 16 mg/L and 14 mg/L alum could be considered the optimum dosage. At this stage, the maximum settling velocity was measured at 3.75 cm/min. and the corresponding settled water turbidity was 2.7 NTU. For design, this settling velocity would translate to a maximum of 1.12 m/h (560 Igpd/sf) which is similar to that obtained in Test 1.

The design settling rates determined from Tests 1 and 2 are similar in magnitude to the actual design overflow rate of 0.95 m/h (475 Igpd/sf)

and confirm that the actual design capacity of the gravity section of the treatment plant is 6,800 m^3/d.

Jar Test 3 was carried out with PACl as the coagulant. Raw water characteristics were: turbidity 40.1 NTU, colour 25 apparent Hazen units, temperature 10°C, and pH 7.98 units. PACl dosages of 2 to 24 mg/L were applied in the test and 8 mg/L appeared to be the optimum dosage for treatment. A lower dosage of 4 mg/L also gave satisfactory results after filtration but settled water turbidity at 5.5 NTU was high at the maximum measured settling velocity of 3.33 cm/min.

For Test 4 raw water turbidity was 30.4 NTU with other parameters being similar to those in Test 3. Again PACl was the coagulant and dosages of 4 to 16 mg/L were applied. The optimum dosage could be considered as falling between 6 mg/L and 8 mg/L PACl.

Even at 6 mg/L excellent settled water clarity (1.96 NTU turbidity) was achieved at a settling velocity of 3.33 cm/min. which would translate to a design rate of 1.0 m/h (500 Igpd/sf). A good filter effluent quality was achieved with all PACl dosages applied in Test 4. This leads to the conclusion that good filter performance also should be achievable at the optimum PACl dosage in full-scale treatment (providing filters meet acceptable design standards).

A comparison of the performance of the two coagulants was carried out in Test 5. Dosages were selected on the basis of optimum dosages established for each coagulant in previous tests. Again, raw water characteristics were similar to those for previous tests, the turbidity being 35.7 NTU. Alum dosages used in the trial were 14, 16 and 18 mg/L while PACl dosages were 7, 8 and 9 mg/L. The optimum alum dosage in this trial could be considered as 16 mg/L. At this dosage and a settling velocity of 3.75 cm/min., the settled water turbidity was 2.6 NTU. Filtration of the settled water produced a filter effluent turbidity of 0.09 NTU.

The test results for PACl in Test 5 indicate an optimum dosage of 7 mg/L and maximum settling velocity of 3.33 cm/min. At this velocity

the settled water turbidity was 1.68 NTu which is somewhat better than the corresponding turbidity for alum coagulation. Filtrate effluent quality at 0.10 NTU turbidity was similar to that obtained with alum.

Conclusions that may be drawn form the jar test trials are as follows:

1. The optimum alum dosage is about 16 mg/L for a raw water turbidity of 30 to 40 NTU, temperature of 10°C, and pH of 7.95 units.

   The corresponding polyaluminum chloride dosage for similar water quality is about 7 mg/L.

2. Maximum settling velocities in the jars resulting in acceptable water quality were established as 3.75 cm/min. for alum and 3.33 cm/min. for PACl. These rates are fairly similar and, based on the latter, would translate to a maximum full-scale design rate of 1.0 m/h (500 Igpd/sf).

3. Although laboratory filter test results do not allow prediction of plant filter design parameters, the results show that good filter performance can be expected at the optimum alum and PACl dosages with a well designed filter.

d) Capability of Existing Plant

The combined rated capacity of the existing Grimsby W.T.P. is 19,300 m^3/d. The gravity filtration plant has a rated capacity of 13,600 m^3/d, and the pressure filtration plant has a rated capacity of 5,700 m^3/d. Average daily flows for 1985 and 1986 were about 6,900 m^3/d and the 1984 average was about 6,000 m^3/d.

The highest daily flow during the three-year study period was 14,026 m^3/d. This represents only 73% of the combined rated capacity of the plant and about 103% of the rated capacity of the gravity filtration plant. On this day, Friday August 2, 1985, the average raw water turbidity was 3.90 NTU, settled water turbidity 1.9 NTU and treated water turbidity 0.14 NTU.

It is doubtful whether plant operations could have been maintained on August 2, 1985 with higher raw water turbidities or without the use of the pressure filters. During the winter period with poor raw water quality and icing conditions existing on the sedimenation basins, operating difficulties with the gravity filtration plant are to be anticipated with flows reaching the design capacity of 6,800 m^3/d.

E.2.2 OPTIMUM PERFORMANCE ALTERNATIVES

As is evident from the existing operational record, reviewed in Section E.2.1 a) above, that the Grimsby W.T.P. has difficulty in consistently meeting the treated water objective for turbidity of less than 1.0 NTU. In 1986, there were 15 days with average daily treated water turbidities of 0.5 NTU and greater, with 6 of these greater than 1.0 NTU and one greater than 10.0 NTU. In 1985, there were 16 days with average daily treated water turbidities of 0.5 NTU or greater, with 5 of these greater than 1.0 NTU. In 1984, there were 13 days with turbidities of 0.5 NTU or greater, with two of these greater than 1.0 NTU.

Several proposals were evaluated for improving treatment performance. The options considered most feasible are presented below in order of priority.

Option 1 - Monitoring and Control of Coagulant Dosage

Wide fluctuations in raw water quality, as reported by the plant staff, could have a significant impact on the ability of the plant to produce acceptable treated water quality on a consistent basis. Automatic control of coagulant dosing would have the beneficial effect of providing for optimum coagulant dosing through a wide range of raw water turbidity.

The current method of chemical dosing involves manually setting the dosage and making adjustments as required. But as shown in the records (Table 2.1, Appendix C) it may not be possible to respond to dramatic changes in raw water turbidity. For example, on May 19, 1986, there

was a sudden change in raw turbidity from 1.20 NTU the previous day, to 30.43 NTU. Because of the lag in coagulant dosage change, the treated water turbidity jumped from 0.17 to 1.42 NTU. Once an appropriate dosage was used, the turbidity was restored to an acceptable 0.22 NTU. It is likely that automatic control of caogulant dosing could have avoided this high treated water turbidity since the flows were below average and only the high raw water turbidity appears to have contributed to the high treated water turbidity.

The Streaming Current Detector (S.C.D.) is a continuous sampling, on-line instrument for monitoring the optimum coagulant dosage relative to a predetermined set-point. The S.C.D. output signal can be continuously recorded and is available for activating high/low alarms and for coagulant feed control. The instrument will indicate coagulant over-dosing and under-dosing and is claimed to be the best instrument currently available for control of the coagulation process.

This option would require a fully equipped S.C.D., new chemical feed pumps with automatic speed and stroke adjustments, and a raw water flow meter and controller.

Option 2 - Rapid or Flash Mixing

At the Grimsby W.T.P. rapid mixing of alum or polyaluminum chloride occurs in the raw water piping between the low lift pumps and the flocculation tanks. Adequate chemical dispersion is not achieved with this type of mixing which must rely on turbulence in the piping and raw water pumps.

The efficiency of coagulation can be improved by the installation of in-line, rapid mixers for each treatment train (gravity plant and pressure filters). The alternative to in-line mixers would be a flash mixer consisting of a pipe injector (or turbine in an open channel). These latter units provide a high degree of mixing at a fraction of a second which is essential for the most efficient use of the coagulant in coagulation.

Option 3 - Flocculant Aid

This option is closely related to Options 1 and 2 above and attempts to improve settling basin performance by the addition of a cationic polyelectrolyte as a flocculation aid.

Consideration should be given to the addition of a cationic polyelectrolyte following coagulation to serve as a flocculation aid. This treatment might reduce the high coagulant dosage required to treat raw water during troublesome periods. The effectiveness of polymer addition should be established through jar tests. Potential benefits may include improved filter performance with respect to both quality and the length of filter runs, and lower overall chemical costs.

Option 4 - Filter Capacity

It appears that filter capacity has limited plant operations during the winter period, probably more so than sedimentation basin capacity which can be manipulated to some degree by the use of a flocculation aid.

Additional filter capacity during the winter is available in the form of the existing pressure filters, providing they can be operated in parallel with the gravity filters on water from the settling basins. Investigations should be carried out to establish feasibility of this proposal and to determine what piping and pumping changes are required to bring the pressure filters into service during the winter.

Option 5 - Pressure Filters

The available filter area consists of 60.5 m^2 of gravity filters and 42.0 m^2 of pressure filters. The pressure filters are used during peak summer demands when raw water turbidity is low, and normally in the direct filtration mode. When raw water turbidity exceeds 20 NTU, the pressure filters can be used in conjunction with the sedimentation tanks.

During normal operation of the pressure filters, coagulant (PACl or alum) is added to the raw water discharge pipe at the pier pump. No

mechanical rapid mix or flocculation facilities exist. Some mixing occurs in the piping to the pressure filters and flocculation may occur in the filter media. Nevertheless, the coagulation and flocculation of colloidal turbidity may be incomplete. Furthermore, raw water turbidity at the pier pump inlet is not monitored on a rigorous basis and the coagulant chemical dosage is manually set with little adjustment for variations in turbidity. For these reasons the effluent quality may not be as good as that from the gravity filters. Better overall performance may be achieved by passing all raw water flows through the pretreatment units (flocculation and sedimentation basins) prior to filtration. This hypothesis should be confirmed through full-scale plant trails.

Option 6 - Filter Operation

1) Filter Rest Period

Improvement in overall treated water turbidity may be possible by improving operations of the filters.

The objective is to reduce or eliminate the initial filter breakthrough which occurs immediately following filter backwashing. This can be achieved, in part, by letting a filter rest for about 15 minutes after a wash before returning the filter to service. The assumption is that during the rest period the filter media will compact and return to conditions similar to those prior to backwashing. If this is so , then the filter should produce water with low turbidity immediately following start-up.

Allowing a filter to rest after backwashing would be simple to implement at virtually no cost. What needs to be established is whether the duty filter(s) will be able to sustain the additional hydraulic load without deterioration in effluent quality for the extended time that the filter being washed is out of service.

2) Hydraulic Surges

Initial high turbidity in the filter effluent can also be caused by hydraulic flow surges. The existing practice of slowly opening the filter effluent valve over two to three minutes should minimize this problem and the practice should be continued.

3) Filter Conditioning

An alternative method for reducing the initial filter breakthrough after a wash cycle is to condition the filter media using alum or a polymer. The coagulant would be applied to the wash water near the end of the backwash cycle. As an example, this procedure of filter conditioning is currently being used at the Toronto Island Filtration Plant with some degree of success.

Implementation of this alternative will require the provision of an alum or polymer feed system capable of applying up to 5 mg/L of alum or 3 mg/L of a non-ionic polymer to the filter backwash water.

4) Filter to Drain

A third alternative for reducing initial filter breakthrough after start-up is to filter to drain. Although simple in concept, this alternative would be difficult to implement at the Grimsby W.T.P. Filter effluent piping would require the addition of filter to drain piping equipped with automatically controlled valves.

As for Option 6 (1), this option would increase the time a filter being backwashed is out of service which may affect effluent quality from the duty filter. In addition, the was water consumption could increase by up to 50 percent over the existing rate.

5) Duration of Filter Backwash

This option is aimed at reducing the amount of filter backwash water used by stopping the wash water cycle automatically based on a pre-

determined level of turbidity in the wash water. The Hach Company is now marketing a backwash water turbidity meter specially designed for measuring the high turbidities in the wash water.

E.3 DISINFECTION

E.3.1 PROCESS EVALUATION

a) Chlorination Equipment

The plant includes a separate gaseous chemical room equipped with the following storage and feed facilities:

- three Wallace and Tiernan V-notch gas chlorinators; one for prechlorination at the pier pump discharge, one for postchlorination of the low lift pump discharge, and one for postchlorination of the filtered water,
- one standby chlorinator which has been disconnected,
- 3 - 2 cylinder scales by Wallace and Tiernan,
- 7 - 68 kg chlorine cylinders, 5 in service, 2 spare, 7 empty.

b) Application Points

Chlorine solution is applied to the pier pump discharge and the main low lift pump discharge for prechlorination. Postchlorination involves application of chlorine solution to the inlet of clear well 1 in the Pumping Station.

c) Dosages and Control

A record of the disinfection practice at the plant is provided in Tables 3.0, 3.1, 3.2, 5.0 and 5.1 of Appendix C. Table E.8 presents a three year summary of chlorine dosages applied and resultant chlorine residuals. Annual average prechlorination dosages were from 1.40 to 1.58 mg/L and the postchlorination dosages from 0.21 to 0.25 mg/L. Applied dosages reflect the chlorine demand which is relatively constant, but slightly higher in summer and early fall.

TABLE E.8

CHLORINATION - 3-YEAR SUMMARY

Parameter	1986 Max.	1986 Min.	1986 Avg.	1985 Max.	1985 Min.	1985 Avg.	1984 Max.	1984 Min.	1984 Avg.
Pre-chlorination									
- chlorine dosage			1.40			1.55			1.58
- free chlorine residual	0.24	0.08	0.14	0.28	0.12	0.19	0.25	0.11	0.17
Postchlorination									
- chlorine dosage			0.21			0.23			0.25
- total chlorine residual	0.66	0.29	0.38	0.51	0.32	0.42	0.54	0.19	0.41

Units in mg/l.

Dosage for pre- and postchlorination are set manually with the objective of maintaining a total chlorine residual in the treated water of 0.3 to 0.4 mg/L.

d) Chlorine Residuals

For prechlorination, the free chlorine residual is monitored on filtered water. During the study period, the average free chlorine residual was 0.17 mg/L with a range from 0.08 to 0.28 mg/L.

The total chlorine residual, after postchlorination, is measured manually six times per day. The average annual total chlorine residual varied from 0.38 to 0.42 mg/L; while the range for the three year period was from 0.19 to 0.66 mg/L.

e) Process Evaluation

Pre- and postchlorination dosages are selected to meet the plant's objective of maintaining 0.3 to 0.4 mg/L of total chlorine residual in the treated water. The prechlorination dosage is applied prior to flocculation and sedimentation but after the low lift pumps.

In additon to disinfection of the water, precholorination at the treatment plant is often necessary to achieve additional objectives including:

- control of taste and odours;
- inactivation and prevention of the growth of algae and bacteria in pretreatment units and in the filter media;
- preventing slimes from developing on the filters;
- oxidation of chemical constituents.

Unfortunately, prechlorination increases the potential for the formation of trihalomethanes (THMs). Since no data for the existing levels of THMs in the finished water were available, no direct comments regarding this potential problem can be made. However, since THMs

levels at other Great Lakes areas are in the order of 30 µg/L (350 µg/L being the current Drinking Water Objective), it can be assumed that the levels at Grimsby also are low. Nevertheless, it is suggested that tests be carried out to establish the level of THMs in the finished water from the Grimsby plant.

The clear water wells have a total volume of 835 m^3; 480 m^3 associated with the pressure filtration plant - clear well 1, and 355 m^3 with the gravity filtration plant - clear well 2. The normal operation of the plant provides for series operation of the clear wells, with post-chlorination in clear well 1 (below pressure filters). Chlorine solution is added to the inlet pipe and can also be added to the bottom of the clear well below the inlet pipe form clear well 2. Clear well 1 also serves as the high lift pumping station wet well. The chlorine contact time, therefore, varies with the water level in the well. At the maximum high lift pumping rate of 13,700 m^3/d (3 electric pumps operating) and high water level in the well, the detention time, assuming complete mixing, would be about 50 minutes. At low water level the detention time would be as low as about 16 minutes. In addition to the variable chlorine contact time, uniform mixing may not be achieved since high lift pump suction headers are spaced along the south wall of the well at right angles to the inlet and point of chlorine addition.

The record for bacterial water quality, both raw and treated, has been compiled in Tables 5.0, 5.1, 7.0 and 7.1 of Appendix C.

Data indicate that, of 142 raw water samples analysed for total coliform content during the three-year study period, 69% contained 1-100 coliforms per 100 mL, 28% contained 101-5000 coliforms per 100 mL and 3% contained more than 5000 coliforms per 100 mL. Of 143 raw water samples analysed for fecal coliform content, 74% contained 0-10 organisms per 100 mL, 25% contained 11-500 organisms and 1% contained more than 500 fecal coliform organisms. Of 114 raw water samples analysed for fecal streptococcus, 43% contained 0-1 organisms, 49% contained 2-50 organisms and 8% contained more than 50 organisms. The

highest total coliform background counts occurred in July or August each year, while higher total coliform and fecal coliform counts generally occurred in late spring and/or late fall.

Treated water data for the three-year study period indicate an absence of coliform organisms in all tests except two tests carried out in December 1985, when total coliform content was analysed to be less than 2 organisms per 100 mL, and one test carried out in September 1986, when a presumptive test was positive.

Test results showed 18 positive tests for total coliform background in treated water. The range for 14 of these positive tests was 1-10 organisms/100 mL. The highest test value recorded was 90,000/100 mL, in June, 1984.

Standard plate count data for treated water indicated the majority of tests in the range of 0-100 organisms per mL. Three tests in the three year study period showed more than 2400 organisms per mL. These were samples taken during June or July of each year.

A summary of the bacteriological data for the study period is presented in Table E.9. These data indicate an acceptable record for disinfection at the plant. During the study period, only one test for total coliform organisms was positive in 1986 and two in 1985.

The efficiency of disinfection is primarily dependent upon the available concentration of free chlorine and contact time. The former is pH dependent since chlorine in water hydrolyzes to form hypochlorous acid which dissociates and is in equilibrium with the hypochlorite ion. As pH increases, the hypochlorous acid concentration decreases, but increases slightly with cold water. At pH greater than 8.0, the hypochlorous acid concentration varies between 22% at 20°C to 30% at 0°C. At pH of 7.5, concentrations are 47% at 20°C and 58% at 0°C. Since the hypochlorite ion has virtually no disinfection capability, it is clear that the efficiency of disinfection can be improved for a given dosage of chlorine by operating at a raw water pH of about 7.5 rather than 8.0 or above.

The raw water at the Grimsby plant has an average pH of 8.3, with a range from 7.9 to 8.6. Generally, the pH is slightly higher in summer than during the rest of the year. The addition of chlorine and alum reduces the pH during treatment by about 0.6 pH units (1984 ad 1985). Chlorine and polyaluminum chlorine reduces the pH by about 0.2 pH units. Therefore, a disadvantage of the use of polyaluminum chloride compared to alum would be its inability to reduce pH in the treated water by as much as for alum resulting in a higher pH and therefore decreased disinfection efficiency. This is particularly important for the Grimsby situation because the pH of the raw water is already greater than 8.0.

Based on the theory of chlorination, it should be possible to improve chlorination efficiency by lowering raw water pH. This can be achieved by adding acid or, with alum as the coagulant, by using acidified alum. The former approach is more complicated and involves using a hazardous chemical. The use of acidified alum would not change existing operations and should be investigated as a feasible alternative to improve disinfection.

Chlorine contact time and mixing can e improved by adding a second postchlorination point to the effluent from the gravity filters at the inlet to clear well 2.

E.3.2 CAPABILITY OF EXISTING PLANT

The existing chlorination facilities and procedures appear to be sufficient for the production of water that is bacteriologically safe.

E.3.3 OPTIMUM DISINFECTION PROCEDURES

Having thoroughly reviewed the current chlorination practice, the following is recommended:

1) TTHM data on treated water should be obtained;

TABLE E.9

BACTERIAL WATER QUALITY - 3-YEAR SUMMARY

	1986		1985		1984	
	No. of Samples	% Total Samples	No. of Samples	% Total Samples	No. of Samples	% Total Samples
RAW WATER						
Total Coliform						
0-100/100 mL	34	69.4	30	62.5	35	71.4
101-5000/100 mL	14	28.6	17	35.4	12	24.5
≥ 500/100mL	1	2.0	1	2.1	2	4.1
Fecal Coliform						
0-10 mL	38	79.2	35	70	35	71.4
11-500/mL	10	20.8	14	28	13	26.5
≥ 500/mL	-	-	1	2	1	2.1
TREATED WATER						
Present/Absent Test						
Total Coliform A	29	93.5	-	-	-	-
P	2	6.5	-	-	-	
TC Positive						
0-4/100 mL	1	-	-	-	-	-
MF Test						
Total Coliform						
Absent	24	100	46	95.8	48	100
1-4/100 mL	-	-	2	4.2	-	-

2) Methods for reducing the finished water pH to about 7.5 should be investigated;

3) In addition to the existing application point, the benefits of chlorinating the gravity filter effluent as it enters clear well 2 should be investigated.

The process changes recommended for further study could be tested on a temporary basis before any modifications are made. It is important, however, that a proper evaluation of the results of the modifications is included as part of the testing procedures, and that modifications are not made unless the desired effect is verified.

E.4 OTHER CONCERNS

E.4.1 TASTE AND ODOUR CONTROL

A yearly summary of average, maximum and minimum values for carbon dosage for the three year record is given in Table 4.0 of Appendix C.

For the study period, the average monthly carbon dosage varied from 1.23 mg/L for February 1984, to 0.46 mg/L for March, 1986. Lower dosages than in previous years are evident for 1986.

A daily taste and odour control profile is given in Table 4.1 for the years 1984 to 1986. Only those months in which carbon was used are included.

It was reported that carbon treatment effectively controls tastes and odours in the treated water at the Grimsby W.T.P.

E.4.2 FLUORIDATION

No fluoride is being added to the treated water at the Grimsby W.T.P. for the reduction of dental decay.

E.4.3 ALUMINUM AND IRON

Neither the raw nor treated water is analyzed for dissolved aluminum.

In view of the significance of aluminum residuals in the treated water, it is suggested that at least weekly tests be carried out to obtain this information.

The only metal for which data are available is iron. Monthly analyses of raw water indicate total iron content in the range of 0.019 mg/L to 18.5 mg/L. The high value occurred during March 1985 when the raw water turbidity was 82 FTU.

Monthly analyses of treated water indicate total iron content consistently less than the 0.3 mg/L drinking water objective. The yearly average was 0.013 mg/L for 1986, 0.016 mg/L for 1985, and 0.025 mg/L for 1984; the range for the three-year record was 0.005 to 0.06 mg/L.

E.4.4 STABILITY OF WATER

The Langelier Saturation Index (L.I.) is commonly used in water conditioning calculations and is defined as:

$$\text{L.I.} = \text{pH} - \text{pHs}$$

where: pH = pH of system as measured by pH meter

pHs = saturation pH at which the total alkalinity and the calcium hardness would be at equilibrium with each other and with solid calcium carbonate.

Temperature and total dissolved solids content will influence the value of pHs. If the L.I. is negative and dissolved oxygen is present, water tends to corrode ferrous piping. If the L.I. is positive and water contains much calcium and alkalinity, deposits and scale may form.

The L.I. for Lake Ontario water at the Grimsby plant varied from about -0.22 in the winter to +0.33 in the summer. For the treated water the L.I. was determined at -0.50 in the winter and +0.22 in the summer. The results show that during the winter while undergoing treatment the water becomes slightly aggressive.

SECTION F

RECOMMENDATIONS

SECTION F - RECOMMENDATIONS

F.1 SHORT-TERM MODIFICATIONS

F.1.1 PARTICULATE REMOVAL

A. Continuous Monitoring of Optimum Coagulant Dosage

Wide and rapid fluctuations in raw water turbidity can have a significant impact on the ability of the plant to produce acceptable treated water quality on a consistent basis. Automatic monitoring of the optimum coagulant dosage would assist in reducing or even eliminating such adverse impact on effluent quality.

Recommendations:

1. Install a Streaming Current Detector (S.C.D.) to monitor the optimum coagulant dosage as determined in the laboratory by jar tests and/or steaming current titrations.

2. Following first-hand experience gained with the operation and performance of a S.C.D., a decision can be reached as to whether automatic dosage control based on a 4 to 20 mA DC output signal from the S.C.D. is warranted. The implementation of this recommendation would require the provision of new chemical feed pumps with automatic speed and stroke adjustment capabilities.

3. The optimum coagulant dosage, which is currently selected on the basis of extensive jar tests and the plant's track record, should be documented including methods of evaluation procedures and actions taken and results, in order to establish a productive tool. Jar test results could be plotted (coagulant dosage versus raw water turbidity) in the form of a dosage chart for use by the operators. With time, the chart can be adjusted to reflect the experience of full-scale treatment.

Estimated Cost:

Recommendation 1:

- Supply and install Streaming Current Detector $14,000

Recommendation 2:

- Supply and install 2 chemical feed pumps with variable speed controller and automatic electric stroke positioner $ 9,000

B. Flash Mixing of Coagulant and Operation of Existing Flocculators

Up to 1986 and partly into 1987 the primary coagulant application point was at the 400 mm dia. suction pipe in the raw water well and directly into the well when low lift pump 1 was not operating (pumps 2 and 3 are supplied by a separate 250 mm dia. suction pipe).

In the Spring of 1987 a second coagulant feed system was located in the low lift pump room. The application point for this system is at the 400 mm dia. common discharge header from all three low lift pumps.

The pier pump intake continues to be dosed by the original installation (in the raw water well house) at a point (on the pier) in the 200 mm dia. discharge pipe from the pump.

Recommendations:

1. The application of coagulant at the Grimsby W.T.P. is inadequate; although the change made in 1987 is an improvement over the original feed point for the main raw water supply. Optimization of the coagulant process, and for the most efficient use of the coagulant chemical, it is necessary to flash mix the chemical with the raw water at a fraction of a second. This high intensity mixing can best be achieved at the Grimsby plant by installing

chemical injector nozzles, one in the 400 mm dia. common discharge header from the low lift pumps and one in the 200 mm dia. raw water header supplying the pressure filters.

2. Operate the existing flocculators at higher speeds in order to increase the efficiency of floc formation and to maximize utilization of the chemical coagulant.

Estimated Cost:

- Supply and install two injector nozzles and make modifications to chemical feed systems $12,000

C. Flocculant Aid and Other Primary Coagulants

The capacity of the settling basins has been exceeded, especially during the summer demand period. With the addition of a flocculant aid to the process flow it is possible to improve settling performance and thereby extend the capacity of the basins. Other benefits associated with the use of a flocculant aid include a reduction in the alum dosage and hence the amount of alum precipitated sludge that will be produced.

Recommendation:

1. In an effort to improve the performance of the sedimentation and filtration processes at the Grimsby plant, many tests have been carried out by representatives of chemical suppliers that market coagulation polymers and polymer preconditioned primary coagulants (i.e., HyperI+on™ by General Chemical Canada Ltd.). Unfortunately, none of the tests with the exception of PACl, proved sufficiently successful to warrant further consideration. For this reason it is recommended that the pretreatment process and unit operations at the Grimsby plant be reviewed in detail by a consulting engineer. Such a study should include a second assessment of the use of flocculant aid polymers and other commercially

prepared primary coagulants. In addition, an in-depth assessment should be made of existing and required mixing facilities.

In Section E of this report it has been concluded that the use of a cationic polymer flocculant aid would be beneficial and result in improved performance of the treatment process. The investigation recommended herein should confirm whether or not polymer storage and feed equipment for the application of a cationic or non-ionic polymer as a flocculant aid should be installed at Grimsby W.T.P.

Estimated Cost:

- Supply and install polymer feed system consisting of:
    - drum storage of neat polymer
    - drum transfer pump
    - 1 - 200 L mixing and solution storage tank
    - 2 - chemical metering pumps with flow proportional controls
    - 1 - mechanical mixer
    - 1 - motionless mixer, piping, valves and rotameter $20,000

D. Operation of Pressure Filters

Two primary concerns relate to the operation of the pressure filters; namely:

- during summer operations poor raw water quality is generally drawn from the pier pump intake,

- over the winter pressure filters are shut down which reduces available filter capacity.

With the use of a flocculant aid settling tanks may give adequate performance at higher hydraulic loading rates to allow pressure filters to

be operated in parallel with gravity filters with effluent from the settling basins.

Recommendations:

1. Studies should be carried out to determine the feasibility of operating pressure filters during the winter with water supplied by submersible pump from the effluent section of the sedimentation tanks.

2. Effluent turbidity from pressure filters should be monitored on a routine basis.

E. Operation of Gravity Filters

Improvement in overall treated water turbidity may be achieved by improving operations of the gravity filters. The objective is to improve performance by reducing the initial filter breakthrough which occurs immediately following a filter backwash.

Recommendations:

1. Continue to let filter rest for about 15 minutes after a wash before returning the filter to service, whenever possible.

2. Continue to minimize hydraulic surges during start up by slowly opening the filter effluent valve.

3. Investigate filtering to drain via the filter drain valve (at low rate) for 15 to 20 minutes as an alternate means of improving filter effluent quality at start-up.

F.1.2 DISINFECTION

Although the record for disinfection is favourable, certain inadequacies exist which, if improved, could lead to a more reliable disinfection process. The two areas where current practice fall short of design objectives are:

- insufficient contact time, and

- inadequate mixing of chlorine solution with the effluent from the pressure filters.

The objective for additional contact time can be achieved by adding chlorine injection points to the discharge of the gravity filters.

Increased contact time for postchlorination of pressure filter effluent can be achieved by chlorinating the individual filter effluent discharges.

Further, the overall efficiency of the chlorination process can be improved by lowering the high water pH and by slightly increasing the post-chlorine dosage.

Recommendation:

1. Examine the feasibility and prepare cost estimates for changing existing post-chlorine application points to the discharge pipes from each filter.

2. Determine the feasibility of adjusting raw water pH, either with the addition of an acid or an acidified coagulant and increasing the post-chlorine dosage, in order to improve the overall efficiency of the disinfection process.

3. Periodically test the treated water for TTHM content. DWSP data for THMs should be examined to determine a future test frequency.

F.1.3 GENERAL IMPROVEMENTS TO PLANT OPERATIONS

A. Intake

Several problems were identified with regard to the size and location of the existing gravity intake, namely:

- raw water quality at the intake is highly variable because of the proximity of the Forty Mile Creek and the shallow lake water depth at the intake crib;

- the actual intake capacity is limited to about 13,000 m^3/d by the high draw-down experienced in the raw water well (indicating that actual head losses incurred by far exceed theoretically calculated values);

- during the winter capacity is severely restricted by frazil ice which gets drawn into the intake. To overcome this problem it has been necessary to greatly reduce flows, thereby limiting intake velocities at the bell mouth, and to backflush the intake, as often as seven times during a single night, with water taken from the distribution system.

Recommendations:

1. The problem with frazil ice formation at the bell mouth can be partially overcome by installing a compressed air system consisting of:

   - 1 - 85 m^3/h capacity air blower, 3 kW motor

   - 1 - 75 mm diameter air line with perforated ring header around bell mouth of intake.

2. Remedial measures for improving raw water quality and intake capacity require the provision of a new intake.

   A recommendation regarding a new intake is made in the following section on Long-Term Modifications.

Estimated Cost:

- Supply and install compressed air package $40,000

B. Taste and Odour Control

The problem of taste and odour in the treated water has been controlled effectively by the addition of powdered activated carbon.

Recommendation:

The practice of using powdered activated carbon treatment for the control of taste and odour in the treated water should be continued.

C. Residual Aluminum

The aluminum content in the treated water is of concern primarily because of the phenomenon of post-floc formation in the distribution system and its resultant impact on the carrying capacity of water-mains.

Recommendation:

Analyze raw and treated water periodically for its aluminum content. Examine DWSP data for aluminum and determine a future test frequency.

F.2 LONG-TERM MODIFICATIONS

F.2.1 MODIFICATIONS TO EXISTING PLANT

The following long-term recommendations for improving the operation of the existing plant are conditional upon the Region of Niagara's future expansion and development plans for meeting future water needs of the service area.

A. Intake

In order to benefit from better and more consistent raw water quality, and to increase capacity, a new larger diameter intake, properly sited in deep water, should be constructed.

Estimated Cost:

- Supply and install 600 mm dia. intake by 450 m long — $500,000

B. Raw Water Flow Meter

In order to monitor and record raw water flows, and to permit quantitative pacing of chemicals, a raw water flow meter should be installed on the 400 mm diameter discharge pipe form the low lift pumps. This meter could be of the ultrasonic, time transient type, and should be equipped with a flow indicating controller, totalizer, signal transmitter and flow recorder.

Estimated Cost:

- Supply and install flow meter complete with all instrumentation — $20,000

C. Flocculation and Sedimentation Basins

In order to improve cold weather operations of the flocculation and sedimentation basins, existing tankage should be covered and weatherproofed. Options to be considered will depend upon the remaining life of the plant and are:

Option 1

Install a low height roof using precast, prestressed, hollow-core slabs, or single or double tees.

Option 2

Enclose the entire tankage in a building equipped with all necessary services. Enclosing of the process units would allow for the future installation of mechanical equipment in floc and sedimentation tanks thereby increasing the performance and capacity of these units.

Estimated Cost:

Option 1:

- Supply roof structure, 12.2 m W x 33.5 m L — $60,000

Option 2:

- Construct fully serviced building (cost will depend upon type and final design of building to be erected) — $400,000 to $750,000

F.2.2 OPTION FOR EXPANDING PLANT CAPACITY

A. Construction of a New Plant

The Grimsby water service area is currently in an expanding growth situation. Proposals have been made to supply the Town of Beamsville and, most recently, the Town of Smithville with water from the Grimsby Water Treatment Plant.

Due to the growth of Grimsby and the potential expansion of the service area, the capacity of the existing treatment plant is inadequate. This has been known for some time, and the Regional Municipality of Niagara is contemplating development of an entirely new treatment plant. As background information to the Region's planning in this regard, the following presents a brief history and conditions of the existing treatment facilities.

The intake, screen house and pumping station which now includes low lift and high lift pumps with standby gasoline and diesel engine drives, pressure filters, chlorine room and administration offices, are very old and represent the original water supply system that was constructed to serve the municipality of Grimsby. These facilities are overcrowded and not suitable for expansion. The intake and raw water well are at the limits of their capacities. Pretreatment units consisting of flocculation tanks and sedimentation basins, and the filter

building housing two gravity filters ad a clear well, were constructed in 1957. These treatment units are separate from the inake works and pumping station by two occupied residential homes. Also, the original design capacities have been exceeded. In 1982 the sand filters were renovated and equipped with dual media in order to increase their capacity by utilizing higher filtration rates. Today the maximum hydraulic capacity of these filters is being realized. The preteatment units, however, have never been expanded.

Recommendation:

In view of the conditions of the existing treatment plant, we endorse the Region's current planning policy for the development of a new water treatment plant on a new site centrally located within the future service area.

APPENDIX A

DAILY RECORD

REGIONAL MUNICIPALITY OF NIAGARA

DAILY RECORD

GRIMSBY WATER SYSTEM

DATE __________ DAY OF WEEK __________

CHEMICALS

TIME	LIQUID ALUM						CHLORINE									
	TANK	USED	DOSAGE				SCALE NO 1		SCALE NO 2		STAND BY		TOTAL USED	DOSAGE mg/L		
			PUMP NO 1		PUMP NO 2		WEIGHT	USED	WEIGHT	USED	WEIGHT	USED	kg	ACTUAL	SET	
	LITRES	LITRES	ACTUAL	SETT	ACTUAL	SETT	kg	kg	kg	kg	kg	kg		TOTAL	PRE	POST
0000																
0800																
1600																
2400																
	TOTAL											TOTAL				

FILTER BACKWASH

FILTER NO	HOURS RUN	HEAD LOSS	EFFLUENT TURBIDITY	BACK WASH	USED		WASH
		M	NTU	TIME	SYSTEM	PUMP	min

WATER TESTS

TIME	RAW	SETTLED		EFFLUENT OF LONGEST RUNNING FILTER						FINISHED POST-CHLORINATED				
	TURBIDITY	TURBIDITY NTU		GRAVITY FILTERS			PRESSURE FILTERS			TURBIDITY	CHLORINE RESIDUAL mg/l			
				FILTER	TURBIDITY	Cl RESID	FILTER	TURBIDITY	Cl RESID					
	NTU	SECT 1	SECT 2	NO	NTU	FREE mg/l	NO	NTU	FREE mg/l	NTU	FREE	COMB	TOTAL	% F/T
0200														
0600														
1000														
1400														
1800														
2200														

FILTER OPERATION

TIME	No 1		No 2		No 3		No 4		No 5	
	SET RATE ____ ML/d		SET RATE ____ ML/d		SET RATE ____ ML/d		SET RATE ____ ML/d		SET RATE ____ ML/d	
	HRS		HRS		HRS		HRS		HRS	
	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP
0000										
0300										
0600										
0900										
1200										
1500										
1800										
2100										
2400										
	HRS		HRS		HRS		HRS		HRS	

ALARMS

DESCRIPTION	TIME	
	RECD	CLEARED

PUMP OPERATION

TIME	LOW LIFT PUMPS										HIGH LIFT PUMPS									
	NO 1		NO 2		NO 3		NO 4		NO 5		NO 1		NO 2		NO 3		NO 4		NO 5	
	13.6 ML/d		4.5 ML/d		5.9 ML/d		5.9 ML/d		5.9 ML/d		2.7 ML/d		5.9 ML/d		5.9 ML/d		5.9 ML/d		4.5 ML/d	
	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP	START	STOP
0000																				
0300																				
0600																				
0900																				
1200																				
1500																				
1800																				
2100																				
2400																				

PUMPS – ELAPSED TIME RUNNING – HOURS

TIME	TREATMENT PLANT										
	LOW LIFT PUMPS					HIGH LIFT PUMPS					BACKWASH
	NO 1	NO 2	NO 3	NO 4	NO 5	NO 1	NO 2	NO 3	NO 4	NO 5	PUMP
2400											
0000											
THIS DAY											

RAW WATER SCREENS CLEANED
TIME

NOON READINGS	OUTSIDE AIR TEMPERATURE	RAW WATER TEMPERATURE	HYDRO PEAK DEMAND

FLOW METERS

TREATED WATER PUMPED PER SHIFT								BACKWASH WATER		RAW WATER PIER PUMP	
2300 - 0700		0700 - 1500		1500 - 2300		TOTAL FLOW TO DISTRIBUTION THIS DAY		READING	LITRES × 1000	READING	LITRES × 1000
PRESENT		PRESENT		PRESENT		2400					
PREVIOUS		PREVIOUS		PREVIOUS		0000					
TOTAL		TOTAL		TOTAL	M³	TOTAL					

WATER LEVELS

TIME	PLANT		DISTRIBUTION SYSTEM		
	RAW WELL	CLEAR WELL	LEVEL	PARK ROAD RESERVOIR	
	M	M		M	TIME
0200			MIDNIGHT		2400
0600			HIGHEST		
1000			LOWEST		
1400					
1800					
2200					

REMARKS

FLOW SUMMARY		RAW WATER	TREATED WATER
MINIMUM RATE	M³/d	______ TIME ______	______ TIME ______
MAXIMUM RATE	M³/d	______ TIME ______	______ TIME ______

SHIFT	SENIOR OPERATOR
2300 0700	
0700 1500	
1500 2300	

DATE ______________________

APPENDIX B

JAR TEST RESULTS

JAR TEST PROCEDURE

1. Obtain sufficient raw water sample to test for raw water quality (turbidity, pH, temperature, colour, alkalinity) and to fill 6 1.5 L glass jars with exactly 1 L of sample.

2. Place all 6 jars in the gang stirrer and begin mix at 100 rpm. Quickly add the desired amount of primary coagulant to each jar. Add the coagulant to the vortex created by the fast stirring paddles. After coagulant has been added to the last jar, continue rapid mix for 60 seconds, then reduce the paddle speed to 30 rpm.

3. If secondary coagulant is to be used as well, quickly add this in the desired amount to each jar during rapid mix. If the secondary coagulant is a polymer, then this should be added after the addition of primary coagulant. If activated silica is used, then the order of addition should be noted.

4. Continue slow mix at 30 rpm for 30 minutes. After 30 minutes, the paddles should be stopped and removed from the jars.

5. Following the start of the slow mix, observe the time of the first appearance of visible floc in each of the six jars, and also the appearance, size and quantity of floc at the end of the agitation or flocculation period.

6. After 30 minutes of slow mix allow the samples to settle. From a fixed depth of 5 cm, the mid-point of the water depth in the jar, collect samples at 1,2, 4 and 8 minutes after the start of settling and analyse samples for turbidity. Samples drawn at these times represent settling velocities of 5, 2.5, 1.25 and 0.625 cm/min. respectively. Plot the results in terms of settling velocity distribution curves.

7. Following the settling period, pipette 200 mL of supernatant from each jar. Use 50 mL to wet a glass fibre filter disc and discard. Filter the remaining sample and measure the turbidity of the finished water. Use a separate filter apparatus and filter disk for each sample from each jar. Use Gelman Sciences Type A/E 47 mm glass fibre filters or Whatman No. 40 filter discs.

GRIMSBY WATER TREATMENT PLANT

JAR TEST RESULTS

RAW WATER CHARACTERISTICS

TURBIDITY : 31.1 NTU
COLOUR : 25 ACU
TEMPERATURE : 10° C
pH : 7.95

JAR TEST NUMBER: 1

JAR NUMBER	COAGULANT and DOSE (mg/L)	FLOC CHARACTERISTICS: Time to 1st floc	Appearance	Size	Quantity	SETTLED WATER SAMPLES: Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	FILTERED WATER SAMPLES Turbidity (NTU)
1	Alum 8	25 min	mostly pin floc; some smaller floc particles forming on particulates	pin	1	2:00	12.6	3:00	9.9	4:35	9.1	10:50	7.5	0.09
2	Alum 12	12 min	small floc; stringy in shape	1 mm	3	1:45	4.5	2:50	3.9	4:25	3.9	10:25	2.5	0.08
3	Alum 16	8 min	floc slightly spherical in shape; floc is more dense than that formed with 12 mg/L	2 mm	3	1:30	3.0	2:40	2.3	4:15	2.2	10:00	1.97	0.06
4	Alum 24	3 min	mostly spherical floc; compact in appearance; size of floc not homogenous	2 mm	4	1:15	2.1	2:30	1.67	4:00	1.21	9:35	0.38	0.05
5	Alum 32	2 min	mostly spherical floc; compact in appearance; size of floc not homogenous	2 mm	4	1:00	4.9	2:20	1.91	3:45	1.45	9:10	0.48	0.03
6	Alum 48	2 min	size is more homogenous than in jars 3,4 and 5; floc not as dense as in jars 3,4 and 5	1 mm	5	0:50	23.3	2.10	6.0	3:30	5.1	8:50	1.07	0.02

GRIMSBY WATER TREATMENT PLANT

JAR TEST RESULTS

RAW WATER CHARACTERISTICS .

TURBIDITY . 31.2 NTU
COLOUR : 25 ACU
TEMPERATURE : 10° C
pH : 7.93

JAR TEST NUMBER. 2

JAR NUMBER	COAGULANT and DOSE (mg/L)	Time to 1st floc	FLOC CHARACTERISTICS: Appearance	Size	Quantity	SETTLED WATER SAMPLES: Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	FILTERED WATER SAMPLES Turbidity (NTU)
1	Alum 10	18 min	slightly larger than pin floc; size not very homogenous; fairly dense	0.5 mm	2	1:40	5.0	2:50	4.7	4:40	4.6	8:40	3.2	0.14
2	Alum 12	12 min	mostly spherical shape; fairly dense; size slightly more homogenous than jar 1, with a tighter structure	1 mm	3	1:30	4.3	2:40	2.5	4:30	2.4	8:30	1.68	0.09
3	Alum 14	8 min	mostly spherical shape; fairly dense; size slightly more homogenous than jar 1, with a tighter structure	2 mm	4	1:20	2.7	2:30	1.58	4:20	1.57	8:20	1.27	0.09
4	Alum 16	6 min	mostly spherical shape; fairly dense; size slightly more homogenous than jar 1, with a tighter structure	2 mm	4	1:10	3.2	2:20	1.46	4:10	1.58	8:10	1.20	0.12
5	Alum 20	4 min	mostly spherical shape; fairly dense; size slightly more homogenous than jar 1, with a tighter structure	2 mm	4	1:00	4.2	2:10	1.44	4:00	1.07	8:00	0.87	0.11
6	Alum 24	4 min	size is more homogenous than in jars 3,4 and 5	2 mm	4	0:50	5.4	2:00	1.43	3:50	1.06	7:50	0.74	0.08

GRIMSBY WATER TREATMENT PLANT

JAR TEST RESULTS

RAW WATER CHARACTERISTICS :

TURBIDITY : 40.1 NTU
COLOUR : 25 ACU
TEMPERATURE : 10° C
pH : 7.98

JAR TEST NUMBER: 3

JAR NUMBER	COAGULANT and DOSE (mg/L)	FLOC CHARACTERISTICS				SETTLED WATER SAMPLES								FILTERED WATER SAMPLES
		Time to 1st floc	Appearance	Size	Quantity	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Turbidity (NTU)
1	PAC 2	25 min	pin floc; some difference in size	pin	1	1:40	13.8	2:50	11.9	4:50	9.7	8:40	8.8	0.16
2	PAC 4	4 min	small floc ; spherical shape; fairly dense, tight structure	1 mm	2	1:30	5.5	2:40	4.0	4:40	3.9	8:30	2.8	0.09
3	PAC 8	40 sec	spherical floc; dense, tight structure; homogenous size	2 mm	4	1:20	1.21	2:30	1.15	4:30	1.10	8:20	1.03	0.04
4	PAC 12	30 sec	spherical floc; dense, tight structure; homogenous size	3 mm	5	1:10	0.64	2:20	0.63	4:20	0.53	8:10	0.49	0.04
5	PAC 16	20 sec	spherical floc; dense, tight structure; homogenous size	3 mm	5	1:00	0.64	2:10	0.32	3:40	0.35	8:00	0.26	0.03
6	PAC 24	10 sec	spherical shape; not as dense as floc in jars 3,4 and 5	2 mm	5	0:50	2.6	2:00	0.24	3:30	0.17	7:50	0.17	0.04

GRIMSBY WATER TREATMENT PLANT

JAR TEST RESULTS

RAW WATER CHARACTERISTICS : TURBIDITY : 30.4 NTU
COLOUR : 25 ACU
TEMPERATURE : 10° C
pH : 7.92

JAR TEST NUMBER: 4

JAR NUMBER	COAGULANT and DOSE (mg/L)	FLOC CHARACTERISTICS: Time to 1st floc	Appearance	Size	Quantity (1 to 5)	SETTLED WATER SAMPLES: Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	FILTERED WATER SAMPLES Turbidity (NTU)
1	PAC 4	10 min	structure more stringy rather than spherical; size not homogeneous; not as dense as floc in jars 2 to 6	1 mm	2	1:40	3.4	2:40	3.1	4:40	3.0	8:40	2.0	0.08
2	PAC 6	2 min	spherical floc; dense, tight structure; homogenous size	2 mm	4	1:30	1.96	2:30	1.72	4:30	1.54	8:30	1.42	0.07
3	PAC 8	1 min	spherical floc; dense, tight structure; homogenous size	3 mm	5	1:20	1.05	2:20	1.06	4:20	1.04	8:20	0.97	0.07
4	PAC 10	30 sec	spherical floc; dense, tight structure; homogenous size	3 mm	5	1:10	0.86	2:10	0.67	4:10	0.68	8:10	0.49	0.06
5	PAC 12	30 sec	spherical floc; dense, tight structure; homogenous size	3 mm	5	1:00	0.65	2:00	0.62	4:00	0.61	8:00	0.49	0.05
6	PAC 16	30 sec	spherical shape; not as dense as floc in jars 3,4 and 5	2 mm	5	0:50	0.96	1:50	0.77	3:50	0.58	7:50	0.45	0.05

GRIMSBY WATER TREATMENT PLANT

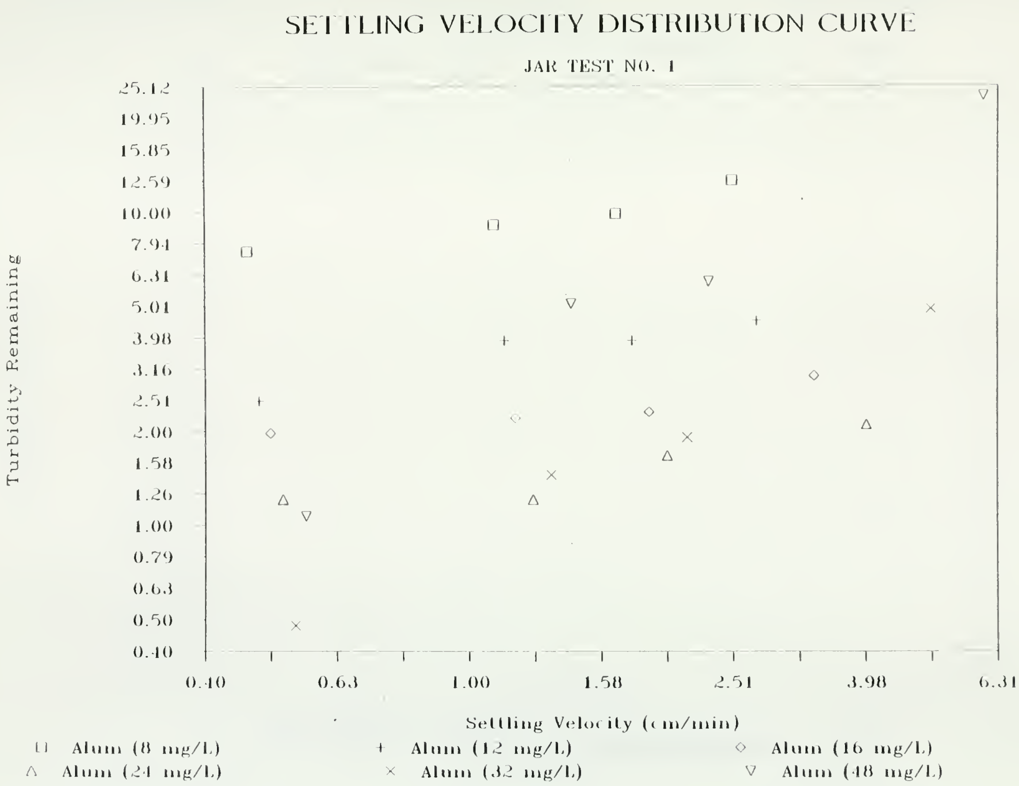
JAR TEST RESULTS

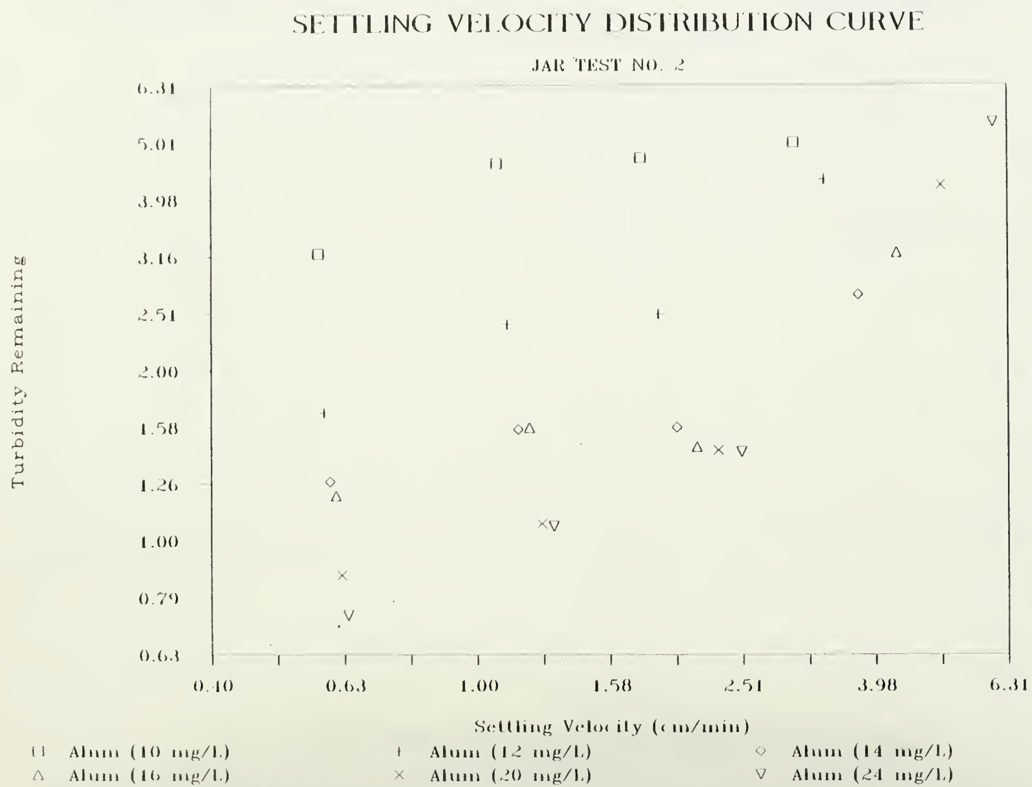
RAW WATER CHARACTERISTICS

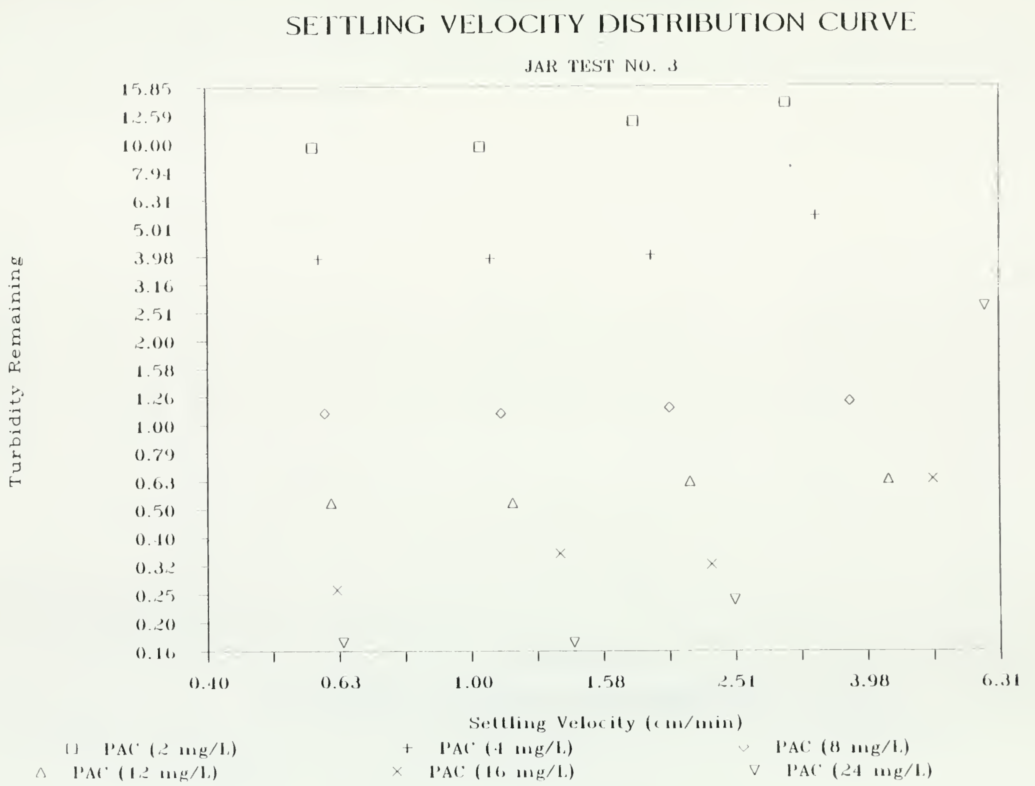
TURBIDITY : 35.7 NTU
COLOUR : 25 ACU
TEMPERATURE : 10° C
pH : 7.95

JAR TEST NUMBER: 5

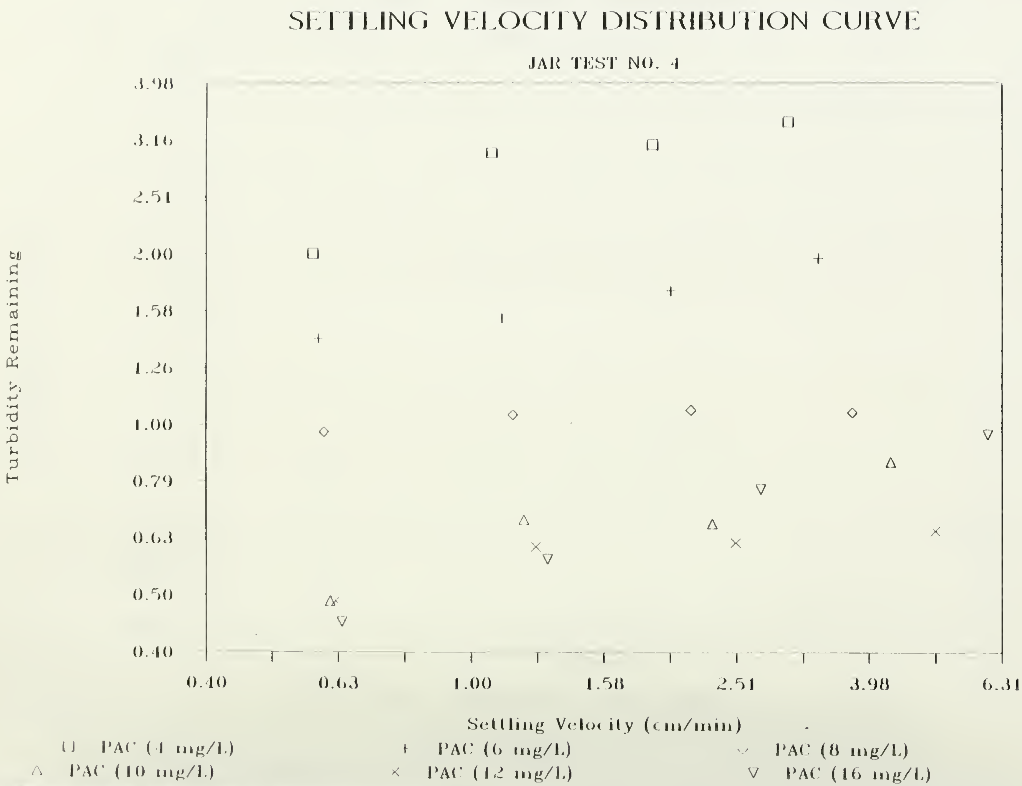
JAR NUMBER	COAGULANT and DOSE (mg/L)	Time to 1st floc	FLOC CHARACTERISTICS: Appearance	Size	Quantity (1 to 5)	SETTLED WATER SAMPLES: Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	Time (min:sec)	Turbidity (NTU)	FILTERED WATER SAMPLES Turbidity (NTU)
1	Alum 14	6 min	structure more stringy rather than spherical; size not homogeneous; fairly dense structure	1 mm	3	1:40	4.2	2:40	3.8	4:40	4.0	8:40	3.2	0.13
2	Alum 16	6 min	spherical floc; not as large or dense as floc formed with PAC; size is fairly homogenous	2 mm	4	1:20	2.6	2:20	2.0	4:20	1.85	8:20	1 48	0.09
3	Alum 18	6 min	spherical floc; not as large or dense as floc formed with PAC; size is fairly homogenous	2 mm	4	1:00	3.6	2:00	2.4	4:00	2.2	8:00	2.0	0.13
4	PAC 7	5 min	spherical floc; dense, tight structure; fairly homogenous size	3 mm	4	1:30	1.68	2:30	1.63	4:30	1.43	8:30	1.33	0 10
5	PAC 8	5 min	spherical floc; dense, tight structure; fairly homogenous size	3 mm	4	1:10	1.61	2:10	1.59	4.10	1.45	8:10	1.38	0.08
6	PAC 9	4 min	spherical floc; dense, tight structure; fairly homogenous size	3 mm	4	0:50	1 43	1:50	1.27	3:50	1.18	7:50	0.83	0.09


SETTLING VELOCITY DISTRIBUTION CURVE
JAR TEST NO. 1
Turbidity Remaining
25.12
19.95
15.85
12.59
10.00
7.94
6.31
5.01
3.98
3.16
2.51
2.00
1.58
1.26
1.00
0.79
0.63
0.50
0.40
0.40
0.63
1.00
1.58
2.51
3.98
6.31
Settling Velocity (cm/min)
Alum (8 mg/L)
Alum (12 mg/L)
Alum (16 mg/L)
Alum (24 mg/L)
Alum (32 mg/L)
Alum (48 mg/L)

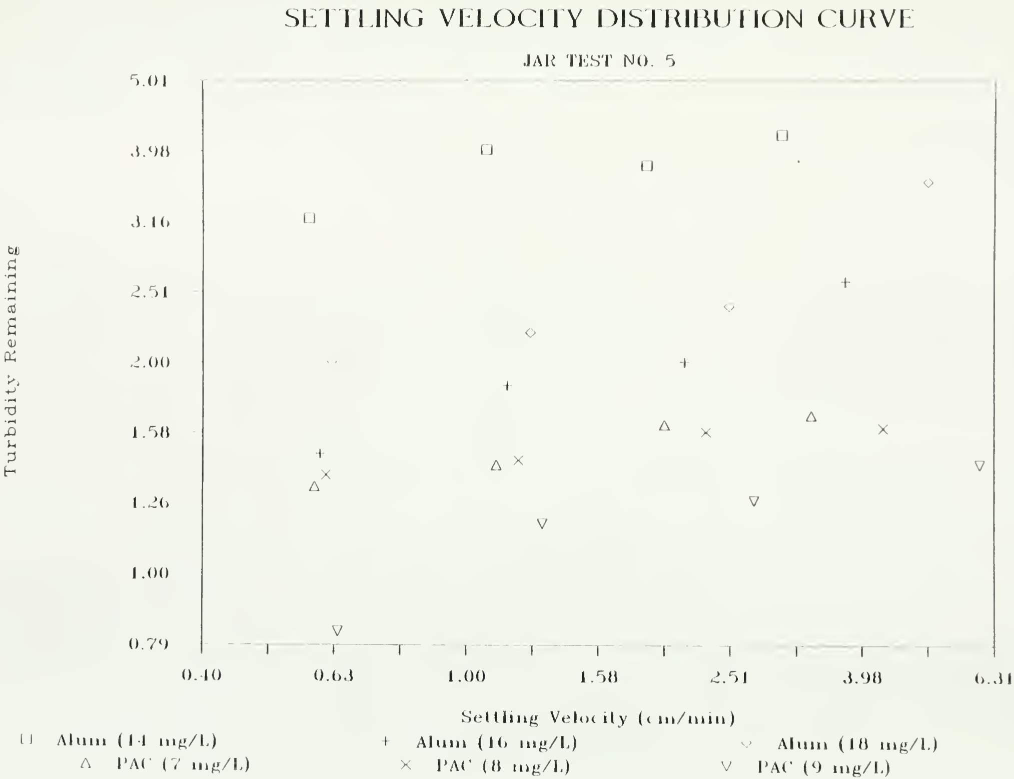

SETTLING VELOCITY DISTRIBUTION CURVE
JAR TEST NO. 2
Turbidity Remaining
6.31
5.01
3.98
3.16
2.51
2.00
1.58
1.26
1.00
0.79
0.63
0.40
0.63
1.00
1.58
2.51
3.98
6.31
Settling Velocity (cm/min)
Alum (10 mg/L)
Alum (12 mg/L)
Alum (14 mg/L)
Alum (16 mg/L)
Alum (20 mg/L)
Alum (24 mg/L)



SETTLING VELOCITY DISTRIBUTION CURVE
JAR TEST NO. 3
Turbidity Remaining
15.85
12.59
10.00
7.94
6.31
5.01
3.98
3.16
2.51
2.00
1.58
1.26
1.00
0.79
0.63
0.50
0.40
0.32
0.25
0.20
0.16
0.40
0.63
1.00
1.58
2.51
3.98
6.31
Settling Velocity (cm/min)
PAC (2 mg/L)
PAC (4 mg/L)
PAC (8 mg/L)
PAC (12 mg/L)
PAC (16 mg/L)
PAC (24 mg/L)



SETTLING VELOCITY DISTRIBUTION CURVE
JAR TEST NO. 4
Turbidity Remaining
3.98
3.16
2.51
2.00
1.58
1.26
1.00
0.79
0.63
0.50
0.40
0.40
0.63
1.00
1.58
2.51
3.98
6.31
Settling Velocity (cm/min)
PAC (4 mg/L)
PAC (6 mg/L)
PAC (8 mg/L)
PAC (10 mg/L)
PAC (12 mg/L)
PAC (16 mg/L)


SETTLING VELOCITY DISTRIBUTION CURVE
JAR TEST NO. 5
Turbidity Remaining
5.01
3.98
3.16
2.51
2.00
1.58
1.26
1.00
0.79
0.40
0.63
1.00
1.58
2.51
3.98
6.31
Settling Velocity (cm/min)
Alum (14 mg/L)
Alum (16 mg/L)
Alum (18 mg/L)
PAC (7 mg/L)
PAC (8 mg/L)
PAC (9 mg/L)

APPENDIX C

TABLES OF OPERATING RECORD

TABLE 1

WATER PLANT OPTIMIZATION STUDY

"PLANT FLOWS"

TABLE 1.0: FLOWS (ML/d)

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JAN	R												
	T	6.599	5.363	6.073	6.101	3.441	4.915	6.073	4.673	5.293			
FEB	R												
	T	7.297	5.724	6.542	6.108	5.159	5.504	6.637	4.591	5.448			
MAR	R												
	T	7.320	5.951	6.564	6.233	4.860	5.547	5.446	4.096	4.796			
APR	R												
	T	7.561	5.830	6.552	7.075	4.790	5.860	5.892	4.387	5.104			
MAY	R												
	T	10.820	6.024	7.914	11.871	5.723	7.735	6.955	4.841	5.577			
JUN	R												
	T	11.332	6.407	7.977	12.310	5.536	8.257	11.297	5.014	7.294			
JUL	R												
	T	13.406	6.015	8.188	13.555	6.015	9.227	11.251	5.510	8.026			
AUG	R												
	T	11.880	4.837	7.916	14.026	5.495	9.461	11.497	5.351	7.860			
SEP	R												
	T	10.579	5.680	7.236	9.317	5.370	7.527	7.660	4.719	6.117			
OCT	R												
	T	7.454	5.609	6.554	7.830	5.197	6.665	7.901	5.023	6.540			
NOV	R												
	T	6.696	5.067	5.641	6.942	4.957	5.805	6.114	4.628	5.192			
DEC	R												
	T	6.546	4.180	5.478	6.540	5.524	5.956	5.528	4.023	4.980			

TABLE 1.1: DAILY FLOWS (ML/d) 1986

MOE WPOS PROTOCOL

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON									10.167			5.553
TUE				6.739			11.004		10.579			5.425
WED	5.386			6.334			7.839		9.979	7.004		5.297
THU	5.384			7.049	6.888		9.710		9.116	7.270		5.324
FRI	6.034			6.454	7.410		9.498	6.887	8.088	7.058		5.554
SAT	6.011	6.039	7.320	6.156	7.293		12.610	4.837	7.535	6.655	6.381	5.442
SUN	5.363	5.724	6.619	6.110	6.559	7.388	13.406	5.807	7.489	6.745	6.403	5.031
MON	6.106	6.107	7.156	6.435	8.208	7.741	10.066	6.896	8.275	6.880	6.053	5.754
TUE	6.075	6.613	6.889	6.565	7.475	7.643	6.867	7.808	8.273	6.876	5.124	5.558
WED	6.209	5.941	6.636	6.227	7.440	8.377	8.371	7.482	6.908	6.889	5.296	5.373
THU	6.570	6.408	6.499	6.028	7.771	6.474	9.730	6.122	5.915	6.959	5.394	5.521
FRI	6.367	6.025	6.850	6.133	7.530	6.451	7.746	6.057	6.318	6.760	5.430	5.303
SAT	6.599	6.320	6.555	6.742	9.129	6.925	6.015	6.296	6.380	7.435	5.473	5.236
SUN	5.853	5.887	6.119	6.744	9.300	7.085	6.139	5.593	5.680	6.587	5.067	5.205
MON	6.170	6.252	7.077	7.300	8.498	8.322	6.884	6.853	6.465	7.355	6.624	5.616
TUE	6.100	6.696	6.047	6.481	8.709	7.469	7.821	6.256	6.493	6.942	5.706	5.133
WED	6.564	6.215	6.294	5.830	7.242	7.015	6.835	7.322	6.062	7.454	5.934	5.798
THU	6.126	6.177	5.951	5.918	8.457	6.504	6.416	6.810	6.711	7.172	5.733	5.091
FRI	6.470	7.033	6.532	7.304	7.091	7.032	6.659	8.139	6.223	5.922	5.286	5.723
SAT	6.378	6.634	6.412	6.808	8.207	7.710	6.315	9.383	5.969	5.973	5.172	5.553
SUN	5.873	6.690	6.010	6.017	9.351	6.407	6.020	9.266	5.898	6.072	5.262	5.228

TABLE 1.1 (cont'd.) 1986

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON	6.156	7.297	6.688	6.335	6.545	7.228	6.750	10.562	6.503	7.138	6.200	5.970
TUE	6.094	6.669	6.268	6.431	6.024	7.069	7.642	11.880	6.424	6.628	5.393	5.845
WED	6.030	7.001	6.340	6.851	7.127	8.324	8.228	10.095	7.310	6.258	6.696	6.085
THU	6.415	7.059	6.953	6.299	6.708	6.988	9.668	10.599	6.782	5.830	5.494	5.462
FRI	5.947	6.932	6.259	6.898	6.161	8.858	9.387	10.779	6.800	6.052	5.263	6.048
SAT	5.884	7.050	6.743	7.446	7.303	11.332	6.485	7.505	7.485	6.070	5.782	4.180
SUN	5.737	6.342	6.143	6.621	8.047	8.336	6.967	8.634	7.245	5.870	5.267	6.105
MON	6.316	7.011	6.338	7.561	8.592	9.462	8.057	10.451	6.748	6.066	6.262	4.985
TUE	6.228	6.933	6.487	6.275	6.877	8.069	7.567	9.017	7.252	5.906	5.537	4.883
WED	6.090	6.832	6.807	6.476	8.166	8.273	8.404	6.878		5.900	5.254	6.596
THU	5.865	6.346	6.020		10.820	11.088	8.725	6.823		5.824	5.481	
FRI	5.947	6.949	6.771		10.500	8.718		7.573		5.609	5.681	
SAT			6.993		9.908	8.821		8.721			5.313	
SUN			6.365			8.268		8.121			5.270	
MON			6.845			9.934						
TUE												
MAX	6.599	7.297	7.320	7.561	10.820	11.332	13.406	11.880	10.579	7.454	6.696	6.546
MIN	5.363	5.724	5.951	5.830	6.024	6.407	6.015	4.837	5.680	5.609	5.067	4.180
AVG	6.073	6.542	6.564	6.552	7.914	7.977	8.188	7.916	7.236	6.554	5.641	5.478

TABLE 1.1: DAILY FLOWS (ML/d) 198_5

MOE WPOS PROTOCOL

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON				5.698			11.136					
TUE	4.301			5.590			9.948			7.279		
WED	4.705			5.610	6.595		11.947			7.830		
THU	4.637			5.935	6.565		13.555	11.713		7.719		
FRI	4.755	5.369	5.546	5.155	7.623		12.895	14.026		7.758	5.692	
SAT	5.128	5.399	5.685	5.381	7.103	6.642	7.143	13.915		7.122	5.685	
SUN	4.314	5.309	5.400	4.790	5.728	7.350	6.735	13.515	5.370	6.358	5.301	5.701
MON	5.128	5.992	5.484	5.471	6.437	8.279	7.566	12.536	6.052	7.663	5.715	5.933
TUE	4.628	5.484	5.674	5.884	6.473	8.186	7.100	12.983	7.179	7.390	5.308	5.970
WED	3.441	5.182	5.583	5.510	6.601	7.810	6.335	8.887	7.631	6.620	5.631	5.674
THU	4.050	5.644	5.241	5.390	6.876	10.231	8.632	10.984	7.162	7.628	5.388	5.546
FRI	4.296	5.784	6.071	5.620	7.902	10.619	6.537	13.733	6.779	7.084	5.483	6.064
SAT	4.591	5.569	5.355	5.500	10.235	10.979	7.183	13.547	7.945	6.757	5.584	5.952
SUN	3.746	5.305	5.491	5.209	8.709	10.259	6.015	13.673	6.011	5.777	4.957	5.798
MON	4.528	6.108	5.249	6.093	10.218	12.310	7.292	12.388	6.863	5.653	5.553	5.978
TUE	4.501	5.410	4.860	6.178	9.747	9.526	6.604	12.202	6.677	6.963	5.363	5.574
WED	4.341	5.642	5.350	6.570	6.545	7.043	7.449	13.023	6.639	6.621	5.572	5.705
THU	4.359	5.369	5.627	5.803	7.951	6.209	8.092	8.272	6.832	6.524	6.198	6.226
FRI	5.308	5.661	6.070	5.503	7.[illegible]26	7.139	7.738	6.822	7.278	6.964	6.203	5.867
SAT	5.135	5.841	5.433	5.703	8.132	7.807	6.842	7.235	7.286	6.308	6.028	6.074
SUN	5.033	5.402	5.295	5.452	7.827	5.901	6.543	6.962	5.494	5.932	5.849	5.619

TABLE 1.1 (cont'd.) 1985

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON	5.258	5.482	5.705	6.768	9.102	6.436	8.448	6.733	7.901	6.873	6.329	5.989
TUE	6.101	5.544	5.995	6.522	7.436	6.594	9.685	6.369	7.796	6.248	6.087	5.941
WED	6.015	5.368	5.725	6.058	6.961	6.547	11.510	7.306	7.894	5.949	6.406	5.783
THU	5.697	5.212	5.744	6.315	8.256	5.536	11.934	7.928	9.259	6.068	6.942	5.889
FRI	5.798	5.385	5.787	5.802	10.525	7.421	10.455	7.866	9.281	6.857	5.918	6.135
SAT	5.502	5.159	5.670	7.075	11.871	6.322	11.631	5.996	8.272	6.284	5.953	6.160
SUN	5.072	5.369	5.073	5.489	7.919	6.281	13.492	5.495	8.779	6.226	5.717	5.859
MON	5.694	5.582	6.117	6.908	6.977	7.766	13.063	6.843	9.317	6.270	5.933	6.292
TUE	5.216	5.545	5.711	6.805	6.915	8.377	13.185	6.517	7.801	5.563	5.610	6.540
WED	5.755		5.621		7.238	9.045	9.337	6.549	7.542	5.197	5.836	5.524
THU	5.336		5.325		7.404	10.270		6.590	7.810	6.129	6.221	6.312
FRI			4.880		6.528	10.487		6.485	7.517		5.817	6.022
SAT			6.233			10.114		5.706	8.096		5.863	6.302
SUN			4.953			9.724			8.220			5.644
MON									8.132			6.035
TUE												6.527
MAX	6.101	6.108	6.233	7.075	11.871	12.310	13.555	14.026	9.317	7.830	6.942	6.540
MIN	3.441	5.159	4.860	4.790	5.728	5.536	6.015	5.495	5.370	5.197	4.957	5.524
AVG	4.915	5.504	5.547	5.860	7.785	8.257	9.227	9.461	7.527	6.665	5.805	5.956

TABLE 1.1: DAILY FLOWS (ML/d) 1984

MOE WPOS PROTOCOL

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON										7.460		
TUE					5.569					7.337		
WED		5.573			5.446			11.497		6.810		
THU		5.746	5.092		5.282			8.346		7.796	5.246	
FRI		5.192	4.796		5.014	5.601		9.342		7.078	5.610	
SAT		6.242	4.855		5.101	8.051		9.851	5.632	6.601	5.132	5.178
SUN	4.809	6.409	4.509	4.728	4.982	5.182	6.119	9.851	4.719	5.737	6.114	4.955
MON	5.719	6.637	4.723	5.151	5.542	7.624	7.746	10.847	5.046	6.237	5.110	5.528
TUE	5.355	5.751	4.732	5.032	5.037	8.165	8.610	9.392	5.992	7.046	5.060	4.987
WED	5.996	5.460	4.914	4.751	5.182	7.628	7.628	8.078	5.459	6.755	4.973	5.296
THU	5.364	5.628	4.773	4.619	5.269	8.328	7.615	6.701	5.987	6.542	5.142	5.069
FRI	5.073	5.887	4.951	4.596	5.182	9.533	6.123	6.142	5.705	6.592	4.828	5.323
SAT	5.073	5.192	4.891	4.387	5.905	10.369	5.569	6.342	6.245	7.051	4.814	4.905
SUN	4.673	5.409	4.691	4.696	4.959	11.297	5.778	5.351	5.173	6.478	4.628	4.669
MON	5.587	5.282	4.751	5.105	5.492	10.679	7.355	6.478	6.069	6.742	5.132	5.205
TUE	5.273	5.264	5.014	5.514	5.269	11.160	5.510	6.892	5.669	7.396	4.910	4.992
WED	5.082	4.651	5.214	4.869	6.005	10.019	6.783	7.246	6.219	6.246	4.855	4.992
THU	5.351	5.337	4.669	4.878	5.692	6.642	8.451	8.106	5.783	7.174	5.369	5.151
FRI	5.292	5.587	4.578	5.182	5.582	6.001	9.369	7.892	5.859	5.864	5.332	5.114
SAT	4.819	5.332	4.614	5.232	6.492	6.724	8.001	8.496	5.046	7.901	4.992	5.001
SUN	5.196	5.082	4.096	4.937	5.159	5.014	9.442	6.187	4.969	6.614	4.987	4.823

TABLE 1.1 (cont'd.) 1984

TREATED WATER

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MON	5.501	5.278	4.978	4.992	6.810	5.678	7.705	7.910	6.446	6.633	5.592	5.410
TUE	5.309	5.528	4.873	5.269	6.955	5.514	5.546	7.974	6.164	6.696	5.292	5.137
WED	5.419	5.319	4.278	4.919	6.033	6.487	6.587	6.724	6.514	6.055	5.373	4.923
THU	4.882	5.555	4.678	4.855	6.146	6.614	7.501	8.351	6.273	6.924	5.137	5.305
FRI	5.555	5.273	4.764	5.332	6.137	7.001	9.156	8.992	6.733	6.160	5.160	4.969
SAT	5.328	5.242	4.878	5.696	6.096	7.587	8.360	8.783	6.901	5.605	5.009	5.092
SUN	5.005	4.778	4.719	4.559	6.055	5.214	10.106	9.465	6.128	5.023	4.823	4.382
MON	6.078	5.796	4.996	5.228	5.346	6.128	9.547	8.010	6.755	5.614	5.510	5.460
TUE	5.228	4.591	5.446	5.069	4.841	6.159	10.992	6.401	7.660	5.496	5.960	4.028
WED	5.082	4.959	4.978	5.582	4.869	5.619	8.037	5.605	6.674	5.064	4.878	4.819
THU	5.569		4.682	5.578	5.446	5.987	7.805	6.064	7.342		5.028	4.869
FRI	5.387		4.851	5.637		6.301	5.873	6.337	7.369		5.028	5.001
SAT	5.209		4.705	5.587		6.505	9.247		6.610			4.823
SUN	5.123			5.246			10.151		6.378			4.023
MON	5.401			5.892			10.833					4.950
TUE	5.351						11.251					
MAX	6.078	6.637	5.446	5.892	6.955	11.297	11.251	11.497	7.660	7.901	6.114	5.528
MIN	4.67	4.591	4.096	4.387	4.841	5.014	5.510	5.351	4.71	5.02	4.628	4.02
AVG	5.29	5.448	4.796	5.104	5.577	7.294	8.026	7.860	6.11	6.540	5.19	4.980

TABLE 2

WATER PLANT OPTIMIZATION STUDY

"PARTICULATE REMOVAL SUMMARY"

TABLE 2.0: PARTICULATE REMOVAL SUMMARY

MOE WPOS PROTOCOL

Month	Parameter	Units		1986 MAX.	1986 MIN.	1986 AVG.	1985 MAX.	1985 MIN.	1985 AVG.	1984 MAX.	1984 MIN.	1984 AVG.	1983 MAX.	1983 MIN.	1983 AVG.
JAN	Turbidity (FTU) (1)		R	42.00	0.80	14.1	81.50	1.10	22.7	15.00	1.60	5.52			
			T	0.67	0.08	0.26	1.60	0.09	0.27	0.45	0.12	0.22			
	Prime Coagulant (2)	(mg/L)		*	*	*	86.97	19.20	48.76	53.18	17.47	28.90			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.1			8.1			8.4			
			T			7.1						8.3			
	Temperature	(^{o}C)	R	1.5	0	0	2.0	0	0.3	0	0	0			
FEB	Turbidity (FTU)		R	38.60	7.23	18.8	34.83	3.20	18.8	139.30	1.98	20.6			
			T	0.32	0.11	0.18	0.65	0.18	0.36	0.69	0.15	0.28			
	Prime Coagulant	(mg/L)		13.35	5.49	9.86	76.19	28.77	52.12	91.60	15.79	45.11			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.1			8.2			8.2			
			T			7.5			7.5			8.0			
	Temperature	(^{o}C)	R	0	0	0	2.0	0	0.3	2.5	0	0.9			
MAR	Turbidity (FTU)		R	48.30	0.86	12.0	116.20	6.00	33.9	66.80	5.13	22.7			
			T	0.50	0.09	0.21	0.34	0.12	0.40	1.10	0.20	0.39			
	Prime Coagulant	(mg/L)		26.13	2.03	7.92	76.01	27.35	51.12	85.32	33.14	62.05			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.2			8.1			8.4			
			T			7.9			7.4			7.6			
	Temperature	(^{o}C)	R	4.5	0	0.9	4.5	0	1.4	1.0	0	0.1			

	MAX.	MIN.	AVG.
* Liquid Alum	53.49	9.92	34.33
Dry Alum	51.55	30.54	39.93
Polyaluminum Chloride	17.04	7.13	13.26

(1) The unit of measurement at Grimsby is NTU.

(2) Alum used until January 26, 1986, Polyaluminum Chloride thereafter.

TABLE 2.0 (cont'd.)

				1986			1985			1984			1983		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
APR	Turbidity (FTU)		R	69.50	1.01	13.11	144.80	2.10	23.9	125.80	6.70	29.8			
			T	9.54	0.10	0.53	0.37	0.09	0.15	1.97	0.12	0.33			
	Prime Coagulant	(mg/L)		14.88	2.02	6.73	72.44	20.90	38.84	106.07	21.96	64.80			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.4			7.9			8.2			
			T			8.3			7.4			7.4			
	Temperature	(^{o}C)	R	10.0	3.0	5.0	8.5	2.0	5.0	7.5	1.5	4.3			
MAY	Turbidity (FTU)		R	42.43	1.20	4.75	3.60	1.60	2.3	68.00	1.60	12.7			
			T	2.50	0.09	0.30	0.17	0.10	0.13	0.23	0.13	0.18			
	Prime Coagulant	(mg/L)		23.69	1.98	4.85	32.63	15.74	20.64	65.40	13.43	35.70			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.3			8.5			8.3			
			T			8.3			7.8			7.5			
	Temperature	(^{o}C)	R	15.5	5.5	8.8	12.0	7.0	9.1	10.0	5.0	7.0			
JUN	Turbidity (FTU)		R	9.90	0.95	2.25	2.50	1.20	1.69	23.00	1.80	5.9			
			T	0.30	0.07	0.15	0.17	0.09	0.13	0.31	0.12	0.19			
	Prime Coagulant	(mg/L)		8.51	3.34	5.03	24.61	11.22	18.64	53.48	11.29	27.98			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.2			8.3			8.5			
			T			8.2			7.8			7.9			
	Temperature	(^{o}C)	R	14.5	8.0	12.1				16.0	8.0	11.7			

R = Raw, T = Treated

TABLE 2.0 (cont'd.)

				1986			1985			1984			1983		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
JUL	Turbidity (FTU)		R	12.20	1.00	3.16	6.40	1.05	1.78	3.50	1.50	2.0			
			T	0.24	0.07	0.13	0.19	0.11	0.14	0.60	0.12	0.22			
	Prime Coagulant	(mg/L)		11.88	4.32	6.52	24.40	11.80	18.07	36.88	16.99	24.77			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.2			8.6			8.5			
			T			8.2			7.9			7.6			
	Temperature	(^{o}C)	R	20.0	9.0	16.7	18.0	7.0	12.9	16.0	6.5	11.8			
AUG	Turbidity (FTU)		R	20.70	1.65	4.39	33.50	1.10	6.21	25.70	1.50	5.8			
			T	0.19	0.06	0.11	0.28	0.11	0.17	0.21	0.10	0.16			
	Prime Coagulant	(mg/L)		11.69	3.81	6.36	45.53	12.37	24.12	57.36	13.96	32.13			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.3			8.4			8.5			
			T			8.1			7.8			7.9			
	Temperature	(^{o}C)	R	20.0	11.0	17.8	20.0	12.0	17.8	22.5	15.0	19.1			
SEP	Turbidity (FTU)		R	26.20	1.30	4.37	16.85	1.90	5.97	31.80	2.20	9.1			
			T	0.22	0.06	0.10	0.21	0.08	0.12	0.17	0.09	0.13			
	Prime Coagulant	(mg/L)		9.96	3.40	5.92	40.39	11.87	23.57	66.52	20.07	36.56			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.3			8.2			8.2			
			T			8.3			7.5			7.5			
	Temperature	(^{o}C)	R	16.5	11.0	13.6	20.5	15.0	17.5	18.5	11.0	14.8			

R = Raw, T = Treated

TABLE 2.0 (cont'd.)

				1986			1985			1984			1983		
				MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.	MAX.	MIN.	AVG.
OCT	Turbidity (FTU)		R	16.58	1.40	5.58	22.60	1.81	4.35	17.96	1.70	5.79			
			T	0.55	0.06	0.14	0.15	0.07	0.10	0.18	0.09	0.12			
	Prime Coagulant	(mg/L)		16.31	5.44	8.24	44.16	14.34	23.29	45.66	18.27	31.19			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.3						8.2			
			T			8.3						7.4			
	Temperature	(^{o}C)	R	14.5	8.0	11.3	16.0	7.5	10.0	14.0	7.0	10.5			
NOV	Turbidity (FTU)		R	28.50	1.00	8.83	82.30	6.60	35.8	28.30	1.23	6.6			
			T	0.99	0.06	0.14	1.82	0.07	0.18	0.17	0.09	0.12			
	Prime Coagulant	(mg/L)		16.34	3.71	9.09	85.32	28.07	51.93	51.12	16.33	31.23			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R			8.3			8.0			8.2			
			T			8.0			7.3			7.7			
	Temperature	(^{o}C)	R	9.0	2.0	4.6	8.5	4.0	6.3	12.0	3.0	6.5			
DEC	Turbidity (FTU)		R	59.7	3.60	23.3	26.60	1.00	8.1	62.00	1.50	20.1			
			T	10.64	0.08	0.56	0.23	0.08	0.12	–	–	0.25			
	Prime Coagulant	(mg/L)		31.88	4.42	12.37	61.67	9.20	27.24	90.45	17.19	52.90			
	Coagulant Aid	(mg/L)													
	Filter Aid	(mg/L)													
	Metal Res. Al/Fe	(mg/L)	R												
			T												
	pH		R						8.2			8.1			
			T						7.3			7.6			
	Temperature	(^{o}C)	R				5.0	0	1.4	5.0	0.5	2.5			

R = Raw, T = Treated

TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1986.

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU) (2)				COAGULANT (1)	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	0.80	0.87		0.10	16.33							0
2	1.23	1.3		0.20	13.03							0
3	13.66	1.5		0.08	34.26							0
4	35.00	1.8		0.14	48.79							0
5	38.00	2.0		0.13	44.34							0
6	42.00	2.1		0.15	36.39							0
7	22.83	2.6		0.67	53.49							0
8	9.30	2.8		0.21	30.43							0
9	3.80	1.7		0.20	27.49							0
10	2.60	1.4		0.16	20.44							0
11	1.90	1.2		0.15	18.91							0
12	1.50	1.1		0.12	16.25							0
13	21.90	2.1		0.12	28.10							0
14	12.60	1.4		0.12	36.53							0
15	11.50	1.8		0.37	38.16							0

(1) Note: * denotes polyaluminum chloride (PAC)
+ denotes dry alum
all other entries liquid alum

(2) The unit of measurement at Grimsby is NTU.

DATE	TURBIDITY (FTU)				COAGULANT (1)	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	4.45	2.1		0.33	27.35							0
17	2.30	1.4		0.27	24.64							0
18	9.27	3.3		0.19	24.37							0
19	12.58	2.9		0.24	49.66							0
20	22.58	1.6		0.17	46.57							0
21	21.33	2.9		0.45	47.92							1.0
22	18.33	3.9		0.47	+ 31.48/30.54							1.5
23	9.80	2.7		0.28	+ 31.29/51.55							0
24	10.40	2.7		0.41	+ 43.15/46.76							0
25	22.00	3.8		0.45	+ 9.92/38.55							1.0
26	21.30	4.0		0.51	+ 11.08/43.49							0.5
27	35.70	4.6		0.60	+32.32/*14.92							0
28	12.90	2.9		0.23	*16.24							0
29	7.30	2.9		0.18	*13.54							0
30	5.10	3.2		0.14	*17.04							0
31	2.8	1.8		0.14	* 7.13							0

(1) Note: * denotes polyaluminum chloride (PAC)
+ denotes dry alum
11 other entries liquid alum

TABLE 2.1: PARTICULATE REMOVAL PROFILE FEBRUARY 1986.

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	9.00	2.6		0.14	5.49							0
2	13.90	3.5		0.13	8.71							0
3	20.50	3.4		0.15	13.03							0
4	18.50	3.7		0.11	13.01							0
5	15.10	5.4		0.17	6.39							0
6	37.70	5.0		0.14	13.10							0
7	38.60	6.3		0.15	13.01							0
8	22.30	4.3		0.15	10.08							0
9	27.70	5.2		0.19	10.99							0
10	22.50	4.9		0.16	13.35							0
11	25.00	7.2		0.12	8.58							0
12	24.70	8.8		0.16	8.96							0
13	17.67	5.0		0.31	9.75							0
14	11.92	4.1		0.30	11.10							0
15	11.42	4.9		0.18	8.23							0

TABLE 2.1 (cont'd.) FEBRUARY 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	10.25	3.8		0.32	7.54							0
17	15.83	3.3		0.23	10.64							0
18	18.67	4.2		0.19	11.48							0
19	7.73	4.4		0.18	7.81							0
20	6.70	4.6		0.17	8.45							0
21	17.50	4.8		0.14	8.86							0
22	26.30	4.3		0.19	11.42							0
23	22.70	6.0		0.14	9.72							0
24	18.50	5.8		0.13	11.01							0
25	27.50	5.1		0.17	7.57							0
26	19.50	5.7		0.17	11.75							0
27	17.00	4.7		0.19	10.41							0
28	7.23	4.4		0.24	5.62							0
29												
30												
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MARCH 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.42	4.0		0.17	3.94							
2	3.42	3.0		0.15	4.01							
3	2.67	2.6		0.15	4.50							
4	2.98	2.8		0.14	2.89							
5	2.02	2.1		0.24	2.03							
6	24.20	4.1		0.26	6.68							0
7	48.30	6.5		0.24	9.75							0
8	10.40	5.5		0.23	7.85							0
9	4.97	3.8		0.23	5.14							0
10	15.33	8.7		0.22	6.97							0
11	21.17	5.4		0.39	7.24							0
12	23.00	13.6		0.50	8.84							0
13	40.50	3.6		0.17	16.60							0
14	29.50	5.3		0.26	16.09							0
15	21.17	4.4		0.32	13.27							0

TABLE 2.1 (cont'd.) MARCH 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	14.83	4.1		0.27	13.17							0
17	7.82	4.1		0.26	26.13							0
18	10.97	4.3		0.22	10.30							0
19	21.29	6.1		0.34	10.96							1.5
20	19.00	4.8		0.12	10.83							1.5
21	10.30	5.8		0.15	9.29							0
22	7.60	4.7		0.15	7.84							1.0
23	4.20	4.4		0.27	6.59							2.0
24	4.70	3.1		0.12	7.09							1.0
25	8.00	4.1		0.16	7.11							1.5
26	2.30	2.3		0.19	3.74							2.5
27	2.00	1.3		0.12	4.41							3.0
28	1.85	1.1		0.13	3.62							3.0
29	1.02	1.0		0.13	2.61							3.0
30	1.03	1.0		0.15	2.77							3.0
31	0.86	0.9		0.09	3.32							4.5

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	1.01	0.9		0.15	2.02							5.0
2	5.21	2.5		0.23	5.03							5.0
3	20.70	4.1		0.13	6.54							5.0
4	18.50	7.1		0.36	5.25							5.0
5	69.50	3.8		0.13	11.17							6.0
6	40.00	4.2		0.11	11.87							5.0
7	27.00	4.6		0.12	10.85							6.0
8	17.80	5.0		0.11	8.58							5.5
9	12.40	5.7		0.14	5.43							4.5
10	9.40	3.7		0.14	8.46							3.5
11	3.32	2.5		0.21	3.93							3.0
12	3.20	2.5		0.22	4.49							3.0
13	2.63	2.2		0.28	2.30							3.0
14	3.78	2.7		0.23	4.55							3.5
15	4.98	2.5		0.15	5.65							4.0

TABLE 2.1 (cont'd.) APRIL 1986

DATE	TURBIDITY (FTU)				COAGULANT	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	13.78	3.2		0.14	7.20							4.0
17	65.70	23.7		9.54	14.88							5.0
18	10.10	4.3		0.59	11.85							5.0
19	8.02	3.7		0.17	9.20							10.0
20	3.15	3.3		0.14	4.31							5.0
21	5.53	4.5		0.21	5.72							5.0
22	13.42	5.2		0.10	4.87							5.0
23	8.78	4.1		0.10	8.92							5.0
24	7.65	5.5		0.33	9.66							5.5
25	5.02	4.4		0.22	4.64							5.0
26	3.87	3.3		0.48	6.77							5.0
27	2.52	2.2		0.23	5.24							5.0
28	2.43	2.0		0.21	4.14							8.0
29	1.98	1.0		0.41	3.60							6.5
30	2.03	1.6		0.28	4.64							6.5
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MAY 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	4.60	1.5		0.22	4.89							6.5
2	5.30	2.3		0.18	5.13							6.5
3	3.40	2.3		0.18	5.08							5.5
4	2.10	1.4		0.18	4.44							5.5
5	2.00	1.3		0.21	4.36							5.5
6	1.40	1.1		0.13	3.34							6.5
7	1.50	1.0		0.13	2.80							7.0
8	1.39	0.9		0.13	1.98							7.0
9	1.70	1.0		0.24	2.65							6.5
10	1.40	1.0		0.11	2.60							7.0
11	1.20	0.9		0.18	2.59							7.0
12	9.60	2.4		0.11	3.69							9.0
13	4.20	2.4		0.12	3.61							9.0
14	7.50	3.8		0.11	5.29							10.0
15	2.70	2.0		0.14	3.42							9.0

TABLE 2.1 (cont'd.) MAY 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.10	1.6		0.30	2.87							8.0
17	1.70	1.3		0.25	3.05							9.0
18	1.20	1.0		0.17	3.26							8.0
19	30.43	1.2		1.42	3.37							8.0
20	42.43	10.3		2.50	23.69							9.0
21	3.00	8.8		0.22	12.62							9.0
22	1.67	2.5		0.14	6.05							9.5
23	1.62	1.4		0.09	4.41							9.0
24	1.27	1.5		0.09	3.88							10.0
25	2.18	1.7		0.28	3.50							10.0
26	1.23	1.6		0.36	3.99							12.0
27	1.57	1.3		0.17	3.96							10.0
28	1.57	1.3		0.17	4.87							10.0
29	1.20	1.0		0.17	3.82							12.5
30	1.20	1.0		0.29	4.20							15.0
31	2.97	1.6		0.28	7.00							15.5

TABLE 2.1: PARTICULATE REMOVAL PROFILE JUNE 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	1.82	1.4		0.98	7.25							8.0
2	5.50	1.8		0.07	5.65							10.0
3	2.60	1.7		0.18	4.72							11.5
4	1.40	1.2		0.25	3.99							11.0
5	3.00	1.3		0.30	5.73							12.0
6	2.80	1.7		0.18	5.27							11.0
7	2.40	1.3		0.13	4.40							11.0
8	2.40	4.3		0.17	4.21							12.0
9	1.60	1.6		0.13	4.32							12.5
10	1.20	0.9		0.18	3.66							12.0
11	1.30	0.9		0.26	4.08							12.0
12	5.70	2.6		0.14	4.95							12.0
13	9.90	3.4		0.14	6.22							12.5
14	2.80	2.2		0.14	6.42							13.0
15	1.20	1.3		0.11	5.16							13.0

TABLE 2.1 (cont'd.) JUNE 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.50	1.6		0.15	8.51							12.0
17	2.00	1.6		0.10	3.34							13.0
18	2.10	1.5		0.11	5.92							13.0
19	1.42	1.1		0.13	5.86							13.0
20	1.18	1.1		0.15	4.61							13.0
21	1.08	1.0		0.15	4.33							12.5
22	1.02	1.0		0.16	4.01							11.0
23	0.95	1.1		0.20	4.10							11.0
24	1.43	1.3		0.12	4.70							14.5
25	3.58	1.9		0.15	6.41							14.0
26	1.00	1.0		0.07	5.39							13.5
27	1.00	0.8		0.10	4.36							10.0
28	1.10	0.9		0.12	3.85							11.0
29	1.00	0.9		0.10	3.95							14.0
30	1.50	1.2		0.09	5.51							14.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	1.00	3.9		0.14	5.33							15.0
2	1.40	3.5		0.09	4.75							15.0
3	2.30	2.7		0.11	6.39							15.5
4	1.70	1.8		0.11	5.13							15.0
5	1.20	2.2		0.16	4.62							13.0
6	1.10	2.2		0.18	4.37							14.5
7	1.30	1.6		0.21	4.51							15.5
8	1.30	1.6		0.17	4.32							14.0
9	1.40	1.2		0.13	4.84							16.0
10	1.80	1.9		0.10	4.46							17.5
11	7.30	2.1		0.15	7.66							17.0
12	12.20	2.2		0.08	11.00							9.0
13	5.80	2.4		0.07	11.88							14.5
14	5.10	1.6		0.09	9.21							15.5
15	2.40	1.4		0.10	7.28							16.5

TABLE 2.1 (cont'd.) JULY 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.80	3.8		0.13	5.93							17.0
17	2.20	2.1		0.16	5.03							16.0
18	2.13	3.0		0.10	6.73							14.5
19	3.08	2.8		0.12	7.91							13.5
20	2.63	2.2		0.19	6.21							15.5
21	3.11	1.8		0.16	6.51							19.5
22	2.05	1.3		0.09	6.26							18.5
23	1.53	1.1		0.09	6.02							18.0
24	1.80	1.1		0.11	4.78							18.5
25	2.00	1.1		0.12	6.79							15.5
26	2.50	1.1		0.24	6.57							16.0
27	2.60	1.1		0.15	5.33							19.0
28	2.70	2.2		0.12	5.56							15.0
29	4.77	1.4		0.17	6.35							20.0
30	8.90	1.0		0.11	10.63							20.0
31	6.80	1.0		0.09	9.75							20.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE AUGUST 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.80	1.9		0.07	6.32							20.0
2	3.80	2.3		0.08	6.06							19.0
3	3.20	3.1		0.09	6.47							20.0
4	3.10	4.3		0.09	5.77							20.0
5	2.70	2.8		0.09	4.95							19.5
6	2.70	2.3		0.09	5.16							19.0
7	3.30	2.5		0.07	5.77							19.0
8	2.80	2.3		0.09	5.41							17.5
9	2.40	2.6		0.11	6.12							19.0
10	3.20	3.3		0.10	6.07							18.0
11	3.30	2.5		0.10	5.26							17.5
12	3.10	2.9		0.14	6.71							17.5
13	2.50	3.2		0.14	4.92							17.0
14	2.07	2.0		0.12	4.29							13.0
15	1.65	1.7		0.12	4.05							11.0

TABLE 2.1 (cont'd.) AUGUST 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.85	1.8		0.13	5.11							16.0
17	1.92	1.6		0.13	3.82							18.5
18	2.20	2.2		0.15	4.58							18.5
19	4.77	2.1		0.16	8.03							18.0
20	3.80	2.8		0.11	8.29							17.5
21	2.90	2.6		0.09	6.72							19.0
22	20.70	2.1		0.11	10.67							20.0
23	11.60	2.0		0.07	11.69							19.0
24	11.00	1.9		0.06	10.70							18.5
25	8.60	1.8		0.07	10.43							18.0
26	2.90	2.1		0.11	6.51							18.5
27	4.55	2.1		0.19	6.41							18.0
28	6.70	2.5		0.08	6.80							17.0
29	4.40	2.5		0.09	5.71							16.0
30	2.50	2.8		0.12	4.43							16.0
31	1.90	2.7		0.16	3.81							16.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE SEPTEMBER 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.00	3.3		0.19	4.82							16.0
2	1.70	2.3		0.17	6.03							16.5
3	3.20	2.8		0.11	5.53							16.5
4	3.20	1.9		0.08	5.73							16.5
5	2.70	1.6		0.08	5.07							16.0
6	2.00	1.6		0.12	5.49							16.0
7	2.70	1.7		0.12	5.05							16.0
8	2.40	2.6		0.12	5.56							15.5
9	1.60	2.4		0.22	5.44							15.0
10	1.30	2.0		0.10	4.91							14.5
11	1.80	1.9		0.11	4.58							13.5
12	1.40	2.1		0.09	4.58							13.5
13	1.30	2.1		0.07	3.40							12.5
14	1.50	2.8		0.09	5.39							11.5
15	3.90	3.1		0.10	3.92							14.0

TABLE 2.1 (cont'd.) SEPTEMBER 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	10.90	1.4		0.07	9.96							11.0
17	5.20	1.4		0.08	6.59							11.5
18	3.50	1.2		0.08	6.03							12.0
19	2.70	1.3		0.08	5.58							12.0
20	4.50	1.1		0.07	6.57							13.0
21	6.30	1.3		0.06	6.94							11.0
22	4.20	1.7		0.08	6.74							12.0
23	4.80	2.3		0.07	7.05							11.5
24	3.10	2.5		0.08	7.07							12.0
25	2.20	1.9		0.07	6.38							12.0
26	2.20	1.8		0.10	5.68							13.0
27	26.20	2.1		0.07	7.77							13.0
28	14.20	2.6		0.08	8.47							13.0
29	4.90	1.5		0.07	6.01							14.0
30	4.10	1.8		0.11	5.27							14.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE OCTOBER 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	8.30	5.3		0.36	6.13							14.5
2	8.60	5.4		0.55	11.10							14.5
3	6.00	3.4		0.18	9.95							14.0
4	11.10	3.3		0.16	8.50							14.5
5	13.80	2.7		0.09	10.72							14.0
6	15.30	2.2		0.07	12.58							13.5
7	6.40	3.8		0.13	8.29							12.5
8	5.20	3.3		0.52	11.29							12.0
9	11.85	1.7		0.12	16.31							12.5
10	16.58	1.9		0.08	10.78							11.0
11	8.22	2.2		0.08	9.13							11.5
12	2.88	2.1		0.15	8.19							11.5
13	2.40	1.8		0.07	7.87							11.5
14	2.37	1.8		0.06	5.44							12.0
15	3.05	2.1		0.08	6.31							11.0

TABLE 2.1 (cont'd.) OCTOBER 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	3.20	2.2		0.13	7.13							10.5
17	7.90	1.8		0.08	8.46							10.5
18	4.60	1.6		0.09	9.84							10.0
19	1.90	1.5		0.12	7.26							10.0
20	1.70	1.4		0.14	6.67							10.0
21	1.90	1.4		0.10	6.11							10.5
22	1.50	1.6		0.10	5.63							10.5
23	1.40	1.2		0.09	8.16							10.5
24	3.30	1.7		0.08	7.54							10.5
25	3.20	2.0		0.07	6.08							8.0
26	3.40	2.6		0.07	7.28							10.0
27	4.20	2.5		0.08	6.17							10.0
28	4.00	2.8		0.08	6.17							10.0
29	2.90	2.2		0.09	6.88							10.0
30	2.70	1.7		0.07	5.90							10.0
31	3.10	2.1		0.11	7.44							9.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE NOVEMBER 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	1.90	1.3		0.06	6.65							8.5
2	1.40	1.4		0.07	4.96							9.0
3	3.40	2.5		0.12	7.24							8.0
4	3.50	1.7		0.08	8.36							8.0
5	9.80	2.0		0.17	8.52							7.0
6	4.52	2.4		0.11	7.82							7.0
7	2.73	2.0		0.14	8.40							7.0
8	1.82	1.4		0.06	5.65							7.0
9	5.57	2.0		0.09	8.39							7.0
10	3.77	2.1		0.08	7.17							6.5
11	3.92	2.9		0.14	6.37							5.0
12	3.38	2.4		0.11	6.27							5.0
13	3.10	1.9		0.12	7.87							5.0
14	1.40	1.2		0.06	6.52							5.0
15	1.17	1.0		0.10	8.25							

TABLE 2.1 (cont'd.) NOVEMBER 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.00	1.0		0.09	3.71							
17	1.10	0.9		0.08	4.77							4.5
18	10.80	1.1		0.09	6.55							4.0
19	28.50	3.8		0.08	14.38							3.5
20	17.50	2.6		0.07	12.02							3.0
21	24.60	3.3		0.08	13.41							2.0
22	19.00	3.8		0.06	12.24							2.0
23	10.00	3.1		0.12	16.34							2.5
24	9.70	2.6		0.08	10.30							3.0
25	12.80	5.1		0.17	10.83							3.0
26	21.00	5.4		0.41	16.00							3.0
27	27.40	3.4		0.99	8.45							3.0
28	8.80	6.5		0.10	16.12							3.0
29	7.50	4.0		0.11	8.94							3.0
30	13.70	3.3		0.09	10.20							3.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE DECEMBER 1986

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	19.50			0.08	12.80							
2	28.00			0.16	17.33							
3	30.70			0.11	20.55							
4	41.00			0.14	11.44							
5	19.83			0.15	8.34							
6	15.63			0.18	10.79							
7	9.03			0.10	8.40							
8	33.55			0.09	9.49							
9	33.67			0.09	10.13							
10	46.67			0.10	13.15							
11	28.80			0.14	11.31							
12	20.00			0.17	12.61							
13	16.20			0.11	9.15							
14	7.00			0.08	7.51							
15	3.60			0.08	5.71							

TABLE 2.1 (cont'd.) DECEMBER 1986

DATE	TURBIDITY (FTU)				COAGULANT PAC	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	3.70			0.18	4.65							
17	6.60			0.38	8.96							
18	6.90			0.13	11.31							
19	5.60			0.15	7.16							
20	3.90			0.23	5.68							
21	7.70			0.09	5.28							
22	13.50			0.39	9.83							
23	3.60			0.12	4.42							
24	24.5			0.25	9.25							
25	59.7			0.09	13.04							
26	39.2			0.12	13.01							
27	37.27			10.64	29.51							
28	35.8			1.02	22.16							
29	52.0			1.31	21.12							
30	31.7			0.22	31.88							
31	37.5			0.11	17.50							

TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	81.50	2.2		0.13	86.97							2
2	78.30	3.2		0.12	75.42							2
3	64.70	2.7		0.11	72.07							1.5
4	53.70	3.3		0.18	84.43							1.5
5	61.50	2.4		0.29	73.19							1.0
6	18.30	1.5		0.26	45.14							1.5
7	60.30	1.9		0.20	74.87							0.5
8	72.70	5.4		0.22	74.57							0
9	34.50	2.7		0.39	73.97							0
10	36.80	3.1		0.97	83.40							0
11	36.00	4.7		1.60	81.98							0
12	23.80	2.6		0.32	57.68							0
13	12.80	2.0		1.03	68.14							0
14	5.90	1.8		0.13	35.14							0
15	15.40	1.6		0.18	66.60							0

TABLE 2.1 (cont'd.) JANUARY 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	4.80	1.9		0.18	33.95							0
17	3.93	1.6		0.13	32.36							0
18	3.61	1.9		0.27	37.72							0
19	3.01	1.8		0.14	39.14							0
20	3.36	1.6		0.09	26.05							0
21	1.73	1.5		0.11	23.42							0
22	2.05	1.3		0.13	21.71							0
23	1.48	0.9		0.22	24.31							0
24	1.10	1.2		0.15	19.20							0
25	2.70	1.5		0.18	22.82							0
26	4.60	1.3		0.16	40.67							0
27	1.90	1.4		0.13	32.83							0
28	1.20	1.0		0.12	29.15							0
29	1.50	0.9		0.13	33.58							0
30	3.80	1.4		0.11	20.46							0
31	6.20	1.4		0.11	50.54							0

TABLE 2.1: PARTICULATE REMOVAL PROFILE FEBRUARY 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	8.70	1.9		0.28	48.57							0
2	9.80	1.6		0.21	46.86							0
3	10.90	1.7		0.23	49.78							0
4	6.20	2.0		0.65	38.93							0
5	8.70	1.8		0.27	43.26							0
6	22.80	1.6		0.20	60.21							0
7	18.30	2.4		0.40	54.46							0
8	22.00	2.5		0.33	53.40							0
9	11.70	2.3		0.59	52.55							0
10	3.20	1.6		0.18	28.77							0
11	11.50	2.0		0.19	37.78							0
12	41.80	2.0		0.26	68.66							0
13	24.30	2.0		0.22	55.60							0
14	34.83	4.8		0.58	76.19							0
15	33.50	4.4		0.40	53.54							0

TABLE 2.1 (cont'd.) FEBRUARY 1985

DATE	TURBIDITY (FTU)				COAGULANT AIIM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	27.50	3.8		0.62	51.61							0
17	27.00	3.6		0.57	50.97							0
18	20.08	2.9		0.47	47.85							0
19	17.56	2.1		0.34	49.36							0
20	11.15	2.4		0.44	47.11							0
21	7.80	3.6		0.57	47.37							0
22	5.70	2.0		0.18	32.50							0
23	14.60	2.6		0.18	45.41							0.5
24	22.00	3.1		0.29	66.16							2
25	23.50	3.8		0.37	58.27							2
26	21.20	4.1		0.43	66.27							1
27	30.10	2.9		0.38	69.25							1.5
28	19.70	2.7		0.39	58.75							0.5
29												
30												
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MARCH 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AiD	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	6.00	1.9		0.18	31.82							0.5
2	9.00	2.1		0.13	27.35							0.5
3	15.70	1.7		0.14	37.73							0.5
4	83.80	3.3		0.24	59.70							0.5
5	116.20	5.5		0.31	76.01							0
6	76.50	4.5		0.64	63.98							0
7	62.50	4.9		1.03	65.61							0
8	39.80	3.8		0.61	62.11							0
9	35.20	4.1		0.80	67.27							0.5
10	35.30	3.8		0.56	65.32							1
11	29.20	4.3		0.34	62.26							1.5
12	32.00	2.9		0.23	65.08							2
13	21.30	1.8		0.23	59.01							1.5
14	11.30	3.0		0.32	55.25							2
15	13.00	1.8		0.30	52.63							2

TABLE 2.1 (cont'd.) MARCH 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	7.43	2.2		0.22	37.24							2
17	6.76	1.5		0.24	34.54							2
18	32.66	2.4		0.41	56.22							0.5
19	14.75	2.3		0.38	39.58							0.5
20	10.98	2.3		0.34	40.25							1
21	16.50	1.8		0.19	38.27							1
22	16.30	2.1		0.15	40.19							1
23	9.70	2.1		0.13	36.60							1.5
24	35.20	1.9		0.17	!5.02							1.5
25	34.50	2.1		0.19	53.33							1.5
26	25.00	2.7		0.15	45.86							2
27	18.70	2.4		0.13	41.27							2
28	18.50	1.9		0.14	43.78							3.5
29	88.00	19.5		3.4	66.80							4.5
30	34.20	2.1		0.12	52.45							3.5
31	96.00	3.3		0.24	62.21							3.5

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	144.80	9.9		0.34	72.44							2.5
2	126.50	6.8		0.37	67.67							2.5
3	73.30	5.3		0.28	62.84							5.0
4	50.60	3.0		0.20	57.05							4.0
5	62.50	4.2		0.19	56.04							5.0
6	24.80	2.4		0.30	48.92							2.5
7	11.30	1.7		0.18	48.71							5.0
8	9.90	2.1		0.10	39.85							4.0
9	5.40	1.6		0.11	28.34							2.0
10	3.90	1.6		0.10	27.34							2.0
11	4.16	1.9		0.10	22.50							2.5
12	9.21	2.5		0.11	35.72							3.0
13	25.90	1.5		0.09	40.32							3.5
14	25.00	1.9		0.09	46.28							4.5
15	13.50	1.9		0.11	34.15							5.0

TABLE 2.1 (cont'd.) APRIL 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	12.66	1.4		0.09	35.65							5.0
17	18.50	1.6		0.09	45.67							5.0
18	16.60	1.6		0.10	31.53							5.5
19	19.50	1.9		0.09	39.11							6.5
20	12.70	1.9		0.10	34.04							6.5
21	10.05	1.7		0.10	31.97							6.0
22	6.20	1.2		0.11	41.25							6.5
23	4.40	1.2		0.17	40.80							7.0
24	4.10	1.5		0.11	28.13							8.5
25	5.40	1.3		0.10	28.16							8.5
26	4.20	1.0		0.10	27.53							8.0
27	3.70	1.2		0.10	20.90							8.0
28	2.60	1.2		0.13	27.95							8.0
29	2.30	1.3		0.19	22.72							7.5
30	2.10	1.3		0.13	21.52							6.5
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MAY 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.60	1.4		0.12	32.63							7.0
2	2.40	1.2		0.11	18.16							7.5
3	2.10	1.1		0.14	20.52							7.0
4	2.20	1.1		0.10	22.74							7.0
5	2.10	1.0		0.11	25.36							7.0
6	2.40	1.2		0.11	22.92							7.0
7	2.40	1.3		0.12	21.31							8.0
8	2.70	1.2		0.12	32.25							8.5
9	1.82	1.1		0.11	17.87							7.0
10	1.98	1.3		0.14	20.14							8.0
11	1.87	1.3		0.12	17.18							8.5
12	2.12	1.2		0.14	16.99							8.0
13	2.35	1.4		0.17	17.88							8.5
14	2.30	1.2		0.14	19.02							9.0
15	3.05	1.2		0.14	17.65							9.0

TABLE 2.1 (cont'd.) MAY 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.92	1.5		0.11	24.01							9.5
17	2.60	1.5		0.11	20.14							9.5
18	3.00	1.6		0.12	22.72							10.0
19	3.00	1.5		0.12	25.56							10.0
20	2.40	1.3		0.15	19.28							10.0
21	1.80	1.1		0.14	22.70							10.5
22	1.70	0.9		0.12	21.14							9.5
23	1.60	1.2		0.14	17.75							10.5
24	1.70	1.2		0.12	17.50							11.0
25	1.70	1.1		0.13	18.75							11.0
26	1.80	1.0		0.14	17.13							9.0
27	1.80	1.1		0.13	16.33							9.0
28	2.50	1.1		0.14	18.76							11.0
29	2.30	1.1		0.12	17.14							11.0
30	1.80	1.2		0.10	15.74							12.0
31	1.70	1.2		0.15	22.52							12.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE JUNE 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.20	1.0		0.11	24.61							
2	1.80	1.1		0.11	18.04							
3	1.70	1.1		0.11	21.19							
4	1.90	1.2		0.10	19.48							
5	1.70	1.0		0.11	16.60							
6	1.30	1.1		0.13	16.87							
7	1.40	1.2		0.15	24.53							
8	1.60	1.2		0.14	11.22							
9	1.80	1.3		0.15	15.21							
10	1.60	1.5		0.15	21.08							
11	1.50	1.1		0.13	19.28							
12	1.90	1.2		0.14	19.00							
13	2.50	1.3		0.14	20.33							
14	1.80	1.2		0.13	17.83							
15	1.30	1.3		0.13	18.39							

TABLE 2.1 (cont'd.) JUNE 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.20	0.9		0.12	17.41							
17	1.20	1.0		0.13	14.87							
18	1.60	1.1		0.14	20.68							
19	1.50	0.9		0.12	18.10							
20	1.50	1.0		0.12	20.15							
21	1.30	0.7		0.09	15.57							
22	1.40	0.9		0.10	16.02							
23	2.40	1.1		0.10	16.32							
24	1.70	1.2		0.17	17.49							
25	1.40	1.1		0.13	17.33							
26	1.50	1.0		0.12	18.98							
27	1.70	1.2		0.11	19.33							
28	2.30	1.2		0.15	22.43							
29	1.90	1.1		0.14	21.15							
30	2.30	1.3		0.14	19.85							
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.10	1.4		0.15	17.19							15.0
2	1.60	1.2		0.15	15.36							15.5
3	2.00	1.3		0.15	17.07							16.5
4	1.53	1.2		0.17	15.59							17.0
5	1.82	1.4		0.19	19.33							8.0
6	1.78	1.3		0.19	11.95							10.0
7	1.45	0.9		0.14	16.80							14.5
8	1.30	1.1		0.12	11.80							14.5
9	1.23	0.7		0.13	19.00							14.5
10	1.05	0.8		0.13	18.33							18.0
11	1.10	0.9		0.11	16.90							18.0
12	1.40	1.3		0.14	19.57							16.0
13	1.50	1.2		0.14	19.33							10.0
14	1.90	1.3		0.17	21.35							8.5
15	2.00	1.3		0.14	19.92							8.5

TABLE 2.1 (cont'd.) JULY 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	1.30	0.9		0.17	24.40							12.0
17	1.90	0.9		0.16	17.52							14.5
18	2.10	0.8		0.14	21.02							13.0
19	2.20	1.2		0.18	18.72							7.5
20	1.50	0.8		0.12	18.47							14.0
21	1.50	0.9		0.11	16.55							15.5
22	1.60	1.1		0.11	16.47							14.5
23	1.60	1.2		0.13	16.90							15.5
24	1.70	1.1		0.14	20.89							15.0
25	1.80	1.1		0.17	17.83							7.0
26	1.60	1.1		0.17	17.12							7.0
27	1.60	1.2		0.13	16.68							13.0
28	1.50	1.2		0.12	20.31							14.0
29	1.80	1.4		0.13	16.50							11.0
30	1.70	1.2		0.13	21.07							12.5
31	6.40	1.6		0.16	20.14							10.5

TABLE 2.1: PARTICULATE REMOVAL PROFILE AUGUST 1985 .

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.50	1.5		0.13	20.83							12.0
2	3.90	1.9		0.14	29.35							14.5
3	1.10	1.3		0.15	19.05							17.0
4	1.30	1.3		0.15	12.37							18.0
5	1.40	1.1		0.15	21.48							16.0
6	1.40	1.3		0.15	15.05							16.5
7	1.60	1.3		0.16	15.35							16.0
8	2.10	1.4		0.17	17.41							18.0
9	2.20	1.6		0.19	16.37							17.5
10	1.80	1.5		0.18	18.73							17.5
11	3.50	2.0		0.20	24.56							17.5
12	12.00	1.9		0.20	26.49							18.5
13	5.30	2.1		0.24	30.33							17.5
14	3.80	1.9		0.27	26.95							19.5
15	3.70	1.4		0.28	25.39							20.0

TABLE 2.1 (cont'd.) AUGUST 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	4.80	1.9		0.20	25.15							20.0
17	3.90	1.7		0.19	33.44							20.0
18	2.90	0.9		0.17	21.82							19.0
19	2.70	1.3		0.15	18.21							18.0
20	2.80	1.5		0.15	15.85							18.5
21	2.90	1.3		0.15	19.36							18.0
22	2.60	1.5		0.17	15.82							18.0
23	2.30	1.5		0.18	17.44							18.0
24	8.40	1.1		0.15	25.25							18.0
25	33.50	0.9		0.13	45.53							16.0
26	16.30	0.7		0.14	37.79							18.0
27	7.30	0.8		0.11	37.14							19.0
28	3.60	1.0		0.12	22.75							19.0
29	8.76	1.1		0.15	24.03							18.5
30	16.80	1.4		0.14	33.79							18.5
31	24.17	1.3		0.16	34.65							18.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE SEPTEMBER 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	8.53	1.0		0.12	19.56							17.5
2	4.30	1.1		0.12	25.47							18.0
3	3.18	0.9		0.12	21.80							18.0
4	3.10	1.2		0.13	14.83							18.0
5	2.60	1.3		0.13	18.79							19.0
6	2.60	1.2		0.13	19.01							19.0
7	2.30	1.2		0.15	16.48							20.0
8	2.30	1.1		0.17	19.32							20.5
9	11.50	1.0		0.16	32.09							19.0
10	9.50	1.1		0.12	31.43							18.5
11	17.80	0.8		0.10	30.84							19.0
12	12.30	1.9		0.21	27.72							18.0
13	13.30	0.7		0.10	40.39							17.0
14	2.70	1.2		0.10	18.39							17.0
15	1.60	1.4		0.14	20.40							17.0

TABLE 2.1 (cont'd.) SEPTEMBER 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.20	0.8		0.11	23.62							16.5
17	2.20	1.3		0.13	11.87							17.0
18	1.90	0.7		0.12	19.59							17.0
19	2.50	1.0		0.11	21.84							17.0
20	2.60	1.0		0.11	19.98							17.0
21	3.50	1.0		0.12	20.99							17.0
22	5.00	0.9		0.13	28.52							16.0
23	3.00	1.0		0.12	22.20							17.0
24	2.80	0.9		0.12	27.20							17.5
25	2.70	1.1		0.11	20.11							17.0
26	7.55	1.0		0.13	27.93							17.0
27	16.85	1.2		0.13	32.33							16.5
28	12.30	1.1		0.08	29.53							15.0
29	5.30	1.2		0.11	22.19							15.5
30	3.25	0.9		0.09	22.81							15.5
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE OCTOBER 1985.

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AIC	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.68	0.9		0.10	21.86							14.5
2	3.01	0.9		0.11	21.76							15.0
3	4.90	1.0		0.10	19.71							16.0
4	4.40	0.8		0.09	25.96							15.0
5	3.80	1.1		0.15	24.72							12.5
6	2.90	0.9		0.13	18.71							12.0
7	2.70	0.9		0.11	21.50							11.0
8	2.10	1.3		0.13	16.88							10.0
9	1.90	1.1		0.14	16.83							8.5
10	2.20	1.1		0.10	24.92							9.0
11	1.90	0.9		0.11	18.93							9.0
12	3.70	0.9		0.12	17.86							7.5
13	8.90	1.2		0.10	27.95							9.0
14	5.30	1.1		0.09	23.88							8.5
15	4.40	1.3		0.10	27.41							8.5

TABLE 2.1 (cont'd.) OCTOBER 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.80	1.2		0.10	25.85							8.0
17	2.40	1.3		0.10	20.88							7.5
18	2.00	1.1		0.11	14.91							8.0
19	2.20	1.3		0.12	14.34							9.0
20	18.70	1.1		0.11	27.38							9.0
21	12.70	1.2		0.09	40.52							8.0
22	15.50	1.2		0.10	44.16							8.5
23	4.40	1.1		0.10	26.02							9.5
24	2.01	1.1		0.11	16.64							9.5
25	1.90	1.1		0.09	19.00							10.0
26	1.81	0.9		0.07	20.74							10.0
27	2.36	1.1		0.08	15.77							10.0
28	4.41	1.0		0.09	20.65							10.0
29	3.56	0.8		0.09	24.68							9.0
30	10.03	1.0		0.08	26.57							8.5
31	22.60	0.7		0.08	34.87							9.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE NOVEMBER 1985.

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	47.80	1.6		0.08	44.53							8.5
2	25.80	1.6		0.09	39.53							8.5
3	31.80	1.6		0.07	42.79							8.0
4	56.50	1.3		0.10	48.19							8.0
5	82.30	1.2		0.14	59.37							8.0
6	46.50	1.5		1.82	60.96							7.5
7	46.30	1.9		0.17	85.32							8.0
8	23.20	1.9		0.08	49.03							7.5
9	33.30	1.7		0.10	63.29							7.0
10	31.20	1.6		0.10	50.44							7.5
11	51.60	2.9		0.14	68.77							6.0
12	33.00	2.8		0.09	55.40							6.0
13	6.60	4.8		0.13	28.07							6.0
14	28.20	2.2		0.46	47.55							6.0
15	22.90	1.7		0.09	54.24							6.0

TABLE 2.1 (cont'd.) NOVEMBER 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	25.80	1.9		0.09	57.35							5.0
17	56.00	6.3		0.15	60.38							5.0
18	51.00	1.6		0.30	71.21							5.0
19	31.80	2.1		0.21	67.90							6.5
20	26.80	1.5		0.17	63.29							7.5
21	8.15	1.6		0.12	34.38							7.0
22	39.83	2.1		0.13	38.29							6.0
23	33.33	1.3		0.11	57.24							5.5
24	28.66	2.8		0.13	39.30							5.5
25	17.33	8.0		0.11	42.05							5.0
26	37.33	5.9		0.08	44.86							4.5
27	23.50	1.4		0.08	55.97							5.0
28	58.50	1.5		0.09	45.89							4.0
29	38.80	1.0		0.10	44.47							5.0
30	29.00	1.0		0.11	37.74							5.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE DECEMBER 1985

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	24.20	2.4		0.12	40.86							5.0
2	26.20	2.4		0.13	54.67							4.0
3	15.50	1.5		0.11	46.74							3.5
4	26.60	4.3		0.21	40.87							1.0
5	25.16	4.7		0.18	61.67							2.5
6	17.83	2.4		0.19	41.34							3.0
7	15.16	1.8		0.13	34.81							2.5
8	5.53	1.3		0.12	26.43							3.0
9	6.05	2.0		0.12	24.56							3.0
10	6.36	2.0		0.11	26.36							3.0
11	8.18	2.1		0.10	26.52							4.0
12	13.90	1.7		0.08	32.75							3.0
13	10.70	1.3		0.09	29.29							0
14	7.70	1.8		0.15	25.85							2.0
15	9.10	2.6		0.15	19.52							2.0

TABLE 2.1 (cont'd.) DECEMBER 1985

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	4.50	2.1		0.10	21.60							1.0
17	3.30	1.3		0.12	29.51							0.5
18	3.50	1.9		0.16	26.33							0.5
19	2.03	1.9		0.23	24.29							0
20	4.76	3.1		0.14	23.00							0
21	1.96	1.3		0.11	17.78							0
22	1.95	1.5		0.11	17.49							0
23	1.48	1.3		0.09	11.41							0.5
24	2.05	1.5		0.10	18.62							0.5
25	1.21	1.3		0.08	17.60							0
26	1.20	1.2		0.11	11.64							0
27	1.30	1.1		0.10	12.37							0
28	1.20	1.2		0.10	15.78							0
29	1.21	1.1		0.11	12.85							0
30	1.00	1.1		0.11	9.20							0
31	1.00	0.9		0.09	42.58							0

TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1984 .

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.18	4.3		0.22	27.74							0
2	2.05	2.6		0.22	30.10							0
3	1.85	2.1		0.19	21.71							0
4	1.82	2.1		0.14	20.27							0
5	1.60	2.8		0.23	21.16							0
6	2.80	1.9		0.18	22.06							0
7	9.00	1.8		0.15	35.02							0
8	3.70	2.3		0.12	28.83							0
9	3.00	1.9		0.14	26.91							0
10	11.88	2.4		0.17	37.70							0
11	15.00	2.3		0.45	50.22							0
12	12.00	2.6		0.33	34.55							0
13	12.50	2.2		0.17	38.33							0
14	14.90	2.1		0.25	53.18							0
15	9.80	2.1		0.19	33.71							0

TABLE 2.1 (cont'd.) JANUARY 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	7.20	2.3		0.31	39.54							0
17	5.00	2.0		0.29	31.52							0
18	3.20	2.4		0.17	25.51							0
19	4.20	1.9		0.22	24.34							0
20	4.08	2.1		0.35	31.82							0
21	3.92	1.9		0.36	27.83							0
22	3.50	1.8		0.38	27.20							0
23	2.62	1.6		0.30	21.32							0
24	2.28	1.6		0.19	20.73							0
25	2.70	1.6		0.15	22.16							0
26	2.00	1.6		0.14	17.47							0
27	3.92	1.5		0.13	21.66							0
28	3.00	1.7		0.21	26.38							0
29	3.83	1.7		0.16	26.50							0
30	4.28	1.4		0.18	24.41							0
31	11.17	1.7		0.24	25.97							0

TABLE 2.1: PARTICULATE REMOVAL PROFILE FEBRUARY 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	6.20	3.3		0.18	37.21							0
2	6.40	2.5		0.22	35.78							0
3	3.30	1.9		0.26	28.61							0
4	4.20	2.4		0.51	28.68							0
5	3.50	2.3		0.26	31.47							0
6	3.30	2.2		0.19	25.02							0
7	3.70	2.4		0.24	26.50							0
8	1.98	1.9		0.21	21.38							0
9	2.75	1.9		0.16	15.79							0
10	5.20	2.3		0.15	24.46							0
11	3.90	2.0		0.15	31.11							0.5
12	8.80	3.0		0.18	34.77							0.5
13	13.30	2.8		0.41	49.82							0.5
14	82.50	5.4		0.23	66.28							1.0
15	37.60	5.0		0.29	68.61							1.0

TABLE 2.1 (cont'd.) FEBRUARY 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	36.17	4.6		0.69	91.60							1.0
17	36.17	4.2		0.65	77.88							1.5
18	31.50	5.1		0.33	70.87							1.5
19	24.50	3.4		0.27	70.04							2.0
20	12.07	2.3		0.32	40.78							2.5
21	11.95	2.7		0.34	39.38							2.0
22	8.90	2.5		0.21	34.77							1.5
23	4.67	1.9		0.24	37.46							2.0
24	3.68	1.6		0.18	37.87							2.5
25	12.90	1.9		0.28	50.66							2.0
26	3.53	1.6		0.25	40.85							1.5
27	8.07	1.5		0.21	41.66							1.0
28	78.16	2.5		0.27	75.86							0.5
29	139.30	4.2		0.15	74.97							0.5
30												
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MARCH 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	44.80	3.5		1.10	81.01							0
2	14.60	2.1		0.45	64.36							0
3	13.80	2.3		0.43	50.89							0
4	12.70	2.3		0.43	47.75							0
5	20.80	2.1		0.38	66.46							0
6	19.20	2.6		0.42	52.90							0
7	14.00	2.0		0.41	55.69							0
8	30.90	2.1		0.36	59.77							0
9	29.50	2.3		0.37	67.55							0
10	20.30	3.0		0.71	60.85							0
11	19.20	1.8		0.31	57.79							0
12	6.80	1.6		0.30	45.13							0
13	17.20	2.0		0.29	51.64							0
14	9.80	2.1		0.34	44.58							0
15	5.13	2.9		0.26	33.14							0

TABLE 2.1 (cont'd.) MARCH 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	8.23	2.0		0.20	44.71							0
17	16.08	2.3		0.25	57.99							0
18	27.83	2.1		0.31	75.30							0
19	16.87	2.3		0.30	60.37							0
20	17.30	2.6		0.35	53.92							0
21	21.00	2.0		0.31	75.47							0
22	22.50	2.5		0.43	68.23							0
23	27.80	3.4		0.73	79.52							0
24	29.20	3.8		0.37	66.74							0
25	15.00	2.6		0.39	63.74							0
26	22.20	2.5		0.52	75.92							0
27	24.70	3.3		0.38	65.35							0
28	43.00	2.3		0.29	79.54							1.0
29	66.80	3.0		0.32	85.32							1.0
30	46.80	2.9		0.23	73.80							1.0
31	19.00	2.6		0.20	58.17							1.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE APRIL 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	17.80	2.2		0.30	67.35							1.5
2	15.70	2.2		0.26	46.97							2.0
3	20.50	2.6		0.20	61.47							2.5
4	24.50	2.1		0.18	55.48							2.5
5	125.80	9.5		0.55	83.47							3.0
6	25.80	3.7		0.63	77.20							3.0
7	51.50	4.6		0.98	103.09							3.5
8	35.80	3.3		0.30	88.99							2.0
9	38.50	4.5		1.97	106.07							3.0
10	43.80	2.9		0.26	77.41							3.0
11	31.50	3.1		0.23	75.20							3.5
12	35.83	3.7		0.37	87.98							3.5
13	31.00	2.0		0.29	73.14							4.0
14	40.33	2.2		0.18	72.31							5.0
15	40.67	2.8		0.23	74.5							5.0

TABLE 2.1 (cont'd.) APRIL 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	45.20	2.1		0.19	74.34							5.0
17	25.70	2.3		0.35	73.00							4.5
18	27.00	1.8		0.29	63.56							4.5
19	18.00	1.7		0.16	53.32							5.0
20	13.90	1.7		0.14	46.36							5.0
21	14.10	1.7		0.23	48.72							4.5
22	30.40	1.5		0.25	65.72							5.0
23	41.00	1.8		0.17	63.70							6.0
24	27.20	2.1		0.13	65.26							5.5
25	10.10	2.3		0.20	61.41							5.0
26	14.20	1.8		0.20	45.00							5.0
27	12.00	1.8		0.13	21.96							5.5
28	12.30	1.4		0.14	47.66							7.5
29	8.00	1.6		0.12	31.65							6.5
30	6.70	1.7		0.15	31.04							6.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE MAY 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (°C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	6.20	2.3		0.13	29.00							6.5
2	2.90	1.3		0.18	28.82							5.0
3	16.80	1.3		0.16	41.58							5.0
4	41.80	2.3		0.19	34.27							5.5
5	23.80	2.2		0.23	58.56							5.0
6	21.70	2.2		0.18	50.05							6.0
7	18.00	1.6		0.18	59.91							5.5
8	11.30	1.3		0.18	51.46							6.5
9	9.70	1.8		0.13	41.92							5.5
10	7.48	1.8		0.19	41.86							6.0
11	5.18	1.6		0.22	53.32							6.0
12	4.07	1.6		0.18	27.55							7.0
13	2.43	1.2		0.17	47.75							7.0
14	2.53	1.3		0.16	25.87							6.5
15	23.42	2.6		0.19	40.84							6.0

TABLE 2.1 (cont'd.) MAY 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	32.63	1.8		0.18	49.47							6.5
17	3.70	1.8		0.16	27.33							8.0
18	2.28	1.4		0.17	18.76							6.0
19	2.72	1.5		0.23	24.63							7.0
20	2.70	1.7		0.14	21.24							7.5
21	2.30	1.6		0.16	20.39							7.5
22	1.80	1.5		0.20	13.43							7.5
23	2.40	1.3		0.15	21.59							8.5
24	1.80	1.2		0.15	16.78							8.5
25	1.80	1.2		0.19	15.32							7.5
26	2.20	1.1		0.18	19.04							9.0
27	1.60	1.2		0.15	17.02							10.0
28	9.40	1.1		0.16	28.50							9.0
29	68.00	2.9		0.19	64.83							8.0
30	42.00	2.4		0.17	65.40							8.0
31	18.80	1.9		0.18	50.21							8.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE JUNE 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	7.30	2.8		0.24	20.70							8.0
2	6.80	1.6		0.26	40.75							10.0
3	4.60	1.5		0.19	33.88							9.0
4	3.00	1.3		0.15	24.07							11.0
5	2.50	1.4		0.15	25.15							10.5
6	2.50	1.5		0.21	11.29							10.0
7	3.43	1.6		0.27	21.01							10.5
8	3.10	1.5		0.21	25.85							11.0
9	2.04	1.4		0.18	25.66							9.0
10	2.11	1.5		0.19	19.73							10.5
11	2.10	1.4		0.17	22.49							10.5
12	2.05	1.4		0.19	23.05							10.0
13	2.35	1.4		0.23	21.50							9.0
14	16.90	3.0		0.17	53.48							11.0
15	23.00	2.0		0.16	51.47							11.0

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	4.30	2.0		0.18	16.77							12.0
17	5.00	2.1		0.25	13.54							10.5
18	4.80	2.4		0.30	16.69							10.0
19	7.70	3.6		0.31	35.74							13.0
20	10.80	1.4		0.19	40.87							15.0
21	4.30	1.5		0.16	31.81							14.5
22	4.40	1.3		0.19	32.18							16.0
23	13.30	1.3		0.15	33.56							16.0
24	9.60	1.1		0.16	37.56							15.5
25	14.40	1.1		0.14	39.48							15.5
26	5.90	1.6		0.12	29.05							16.0
27	1.80	1.2		0.13	19.96							7.5
28	2.40	1.3		0.14	24.20							10.5
29	2.20	1.1		0.15	25.18							14.5
30	3.00	1.4		0.17	22.73							14.5
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE JULY 1984 .

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.10	1.1		0.14	28.20							14.5
2	3.50	1.3		0.15	21.62							14.0
3	3.10	1.5		0.14	23.81							15.5
4	2.60	1.5		0.13	17.91							14.0
5	2.50	1.5		0.23	32.70							13.5
6	1.80	1.4		0.15	19.54							14.0
7	1.80	1.3		0.18	22.24							14.0
8	2.10	1.3		0.12	19.28							12.0
9	1.56	1.1		0.16	16.99							12.5
10	1.63	1.1		0.19	20.01							9.5
11	2.06	1.1		0.14	27.64							9.0
12	1.70	1.0		0.14	21.21							10.5
13	1.60	1.2		0.23	21.07							11.0
14	1.80	1.6		0.23	25.22							11.0
15	2.00	1.5		0.24	31.56							10.5

TABLE 2.1 (cont'd.) JULY 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.00	1.7		0.21	25.73							12.0
17	1.70	1.1		0.18	22.51							11.5
18	1.50	1.1		0.16	23.29							12.0
19	1.50	0.9		0.17	22.44							12.0
20	1.90	1.1		0.20	22.13							10.0
21	1.90	1.2		0.25	19.62							11.0
22	1.90	1.3		0.22	21.41							11.0
23	2.00	1.5		0.16	22.20							6.5
24	1.70	1.3		0.21	28.12							11.5
25	1.70	1.6		0.56	27.78							13.5
26	1.60	1.2		0.39	25.12							13.0
27	2.20	1.6		0.60	23.46							10.0
28	2.90	1.7		0.33	35.38							10.0
29	2.10	1.5		0.25	34.26							11.0
30	2.00	1.5		0.25	36.88							10.0
31	2.00	1.4		0.36	28.63							16.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE AUGUST 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	1.90	1.2		0.24	21.53							15.0
2	1.83	1.0		0.20	28.14							16.5
3	2.40	1.3		0.18	13.96							16.5
4	1.50	1.3		0.16	17.24							17.5
5	1.98	1.6		0.18	18.53							19.0
6	1.78	1.6		0.19	22.05							18.5
7	1.76	1.2		0.21	22.48							18.0
8	2.45	1.1		0.19	30.75							20.0
9	3.77	1.5		0.19	23.88							16.0
10	2.77	1.3		0.16	25.38							19.0
11	6.00	1.2		0.18	34.39							19.5
12	6.30	1.4		0.17	41.08							19.5
13	5.70	1.0		0.14	39.78							20.0
14	3.20	0.9		0.20	31.25							20.0
15	3.20	0.9		0.20	30.61							21.5

TABLE 2.1 (cont'd.) AUGUST 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.60	0.9		0.19	27.60							22.5
17	18.30	0.6		0.15	57.36							22.5
18	5.50	0.7		0.10	36.40							21.5
19	17.50	0.8		0.10	43.39							21.0
20	25.70	0.8		0.14	53.94							19.5
21	9.60	1.0		0.11	33.67							20.0
22	6.00	0.9		0.18	34.69							20.0
23	6.70	0.8		0.19	31.39							19.0
24	12.90	0.8		0.11	51.62							19.0
25	6.00	0.9		0.13	38.17							19.0
26	4.70	0.8		0.14	34.60							19.0
27	3.40	0.8		0.12	30.14							19.0
28	3.00	0.7		0.11	30.79							18.5
29	2.70	0.9		0.12	38.77							18.5
30	2.55	0.9		0.14	23.32							19.0
31	3.26	1.0		0.15	29.12							19.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE SEPTEMBER 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	3.41	0.8		0.17	30.47							18.5
2	9.38	0.8		0.12	30.90							11.0
3	22.50	0.7		0.14	59.35							14.0
4	31.33	1.0		0.12	66.52							15.0
5	16.45	1.0		0.13	55.56							15.5
6	9.60	1.1		0.11	39.15							15.5
7	4.10	0.9		0.12	31.56							15.5
8	2.50	0.8		0.15	20.07							15.5
9	2.20	0.9		0.16	28.43							15.0
10	2.20	0.9		0.16	25.48							15.0
11	4.40	0.7		0.15	27.34							15.5
12	6.20	0.9		0.15	26.66							15.0
13	6.20	0.8		0.11	32.63							15.0
14	4.00	0.8		0.12	26.47							15.0
15	31.80	1.1		0.09	43.57							15.0

TABLE 2.1 (cont'd.) SEPTEMBER 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	19.50	1.1		0.09	46.29							15.0
17	18.90	1.7		0.11	42.48							14.0
18	12.90	1.6		0.12	42.92							14.5
19	7.20	0.9		0.13	37.83							15.0
20	3.70	0.7		0.12	38.26							15.0
21	4.80	0.8		0.13	38.31							15.0
22	2.80	0.9		0.11	25.76							15.0
23	2.60	0.7		0.16	28.36							15.0
24	2.60	0.7		0.16	28.30							15.0
25	2.20	0.7		0.15	22.27							15.0
26	10.60	0.9		0.12	43.09							14.5
27	11.83	1.5		0.15	45.11							14.5
28	9.35	1.6		0.14	50.69							14.0
29	5.25	1.2		0.14	30.57							13.5
30	4.48	1.0		0.13	32.28							14.0
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE OCTOBER 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	6.55	1.0		0.13	30.35							14.0
2	8.05	0.8		0.11	37.99							12.5
3	5.91	0.8		0.11	29.86							13.0
4	4.40	0.9		0.11	29.94							12.0
5	17.80	1.0		0.10	32.11							12.0
6	7.90	1.0		0.12	35.27							7.0
7	6.50	1.3		0.13	33.59							7.0
8	5.00	1.6		0.12	29.41							7.5
9	2.60	1.0		0.13	30.26							9.0
10	2.20	1.1		0.13	18.27							9.5
11	2.10	1.0		0.14	25.37							10.0
12	1.90	0.8		0.12	20.36							9.5
13	1.70	0.8		0.10	24.74							10.5
14	1.80	0.9		0.09	21.52							10.0
15	1.90	1.0		0.10	19.91							9.0

TABLE 2.1 (cont'd.) OCTOBER 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	2.50	1.0		0.11	22.44							8.5
17	3.60	1.0		0.18	38.72							10.0
18	6.00	1.0		0.14	40.39							11.0
19	5.00	1.2		0.10	43.26							11.0
20	4.50	1.1		0.13	25.23							11.0
21	11.00	1.0		0.16	41.15							11.0
22	9.70	1.3		0.12	45.47							11.0
23	6.40	1.2		0.11	34.76							11.0
24	3.40	1.2		0.12	26.10							11.0
25	3.35	1.2		0.14	22.52							11.0
26	11.60	1.2		0.12	43.88							11.0
27	3.81	1.3		0.14	24.39							11.0
28	4.80	1.3		0.13	32.25							12.0
29	5.23	1.2		0.13	35.38							11.5
30	4.55	1.0		0.12	26.31							11.0
31	17.96	0.8		0.10	45.66							11.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE NOVEMBER 1984

MOE WPOS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	21.00	0.8		0.10	36.57							11.0
2	23.20	1.1		0.11	44.18							10.5
3	16.20	1.0		0.11	43.92							9.5
4	12.50	1.2		0.13	41.20							12.0
5	5.10	1.3		0.12	25.03							9.5
6	4.10	0.9		0.12	33.09							8.5
7	2.50	1.1		0.10	25.22							8.5
8	2.40	0.9		0.12	25.10							8.0
9	2.60	0.9		0.11	25.12							8.0
10	2.30	0.9		0.14	22.36							8.0
11	3.50	1.1		0.12	25.22							8.5
12	16.70	1.3		0.09	48.01							7.5
13	28.30	1.8		0.11	51.12							6.0
14	7.50	1.5		0.11	49.22							5.5
15	7.10	1.5		0.11	36.31							5.5

TABLE 2.1 (cont'd.) NOVEMBER 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	3.10	1.0		0.11	30.16							6.0
17	2.10	0.9		0.09	22.18							5.0
18	1.80	0.9		0.11	20.97							5.0
19	4.80	1.2		0.15	31.31							5.0
20	7.10	1.7		0.12	40.20							4.5
21	3.50	1.4		0.13	29.50							4.0
22	4.16	1.5		0.13	26.13							3.0
23	2.56	1.1		0.15	30.91							3.5
24	1.50	1.1		0.14	35.81							4.0
25	1.70	1.3		0.17	30.29							4.0
26	1.25	0.9		0.14	16.33							4.5
27	1.23	0.7		0.14	19.20							5.0
28	1.75	0.7		0.15	21.81							5.5
29	2.10	0.8		0.13	23.21							4.0
30	2.90	1.3		0.11	27.13							4.5
31												

TABLE 2.1: PARTICULATE REMOVAL PROFILE DECEMBER 1984

MOE WPDS PROTOCOL

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (0C)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
1	2.40	1.0			24.62							5
2	1.50	0.8			20.84							4.5
3	9.20	1.1			41.45							4.5
4	7.20	1.4			42.33							3.0
5	4.30	1.3			35.58							2.5
6	5.00	1.2			46.82							2.0
7	5.10	1.2			48.00							2.0
8	3.00	0.8			30.14							1.5
9	2.00	0.8			28.89							2.0
10	1.60	1.0			17.19							2.0
11	1.50	0.9			18.49							2.5
12	1.60	1.0			26.76							2.0
13	2.20	0.9			20.33							3.0
14	31.00	1.1			42.84							3.0
15	37.00	1.9			61.87							3.0

TABLE 2.1 (cont'd.) DECEMBER 1984

DATE	TURBIDITY (FTU)				COAGULANT ALUM	COAG. AID	FILTER AID	METAL RES. Al/Fe (mg/L)		pH		TEMP. (oC)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	30.00	1.9			70.43							3.0
17	19.00	1.9			69.13							3.0
18	26.10	2.5			81.49							4.0
19	26.30	2.9			83.98							3.0
20	25.83	2.5			78.84							2.5
21	32.66	2.1			90.40							2.0
22	62.00	3.0			70.05							2.5
23	42.50	2.0			67.77							1.5
24	25.50	2.4			55.86							2.0
25	31.33	1.6			79.53							1.0
26	19.51	1.4			50.98							0.5
27	35.81	1.8			65.37							0.5
28	33.50	2.3			61.75							0.5
29	20.20	2.0			56.52							3.5
30	28.50	5.4			61.15							3.5
31	45.80	5.2			90.45							3.0

TABLE 3

WATER PLANT OPTIMIZATION STUDY

"DISINFECTION SUMMARY"

TABLE 3.0: DISINFECTION SUMMARY (mg/L)

MOE WPOS PROTOCOL

		1986						1985					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			1.00			0.16			1.35			0.22
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.25	0.07	0.19				0.29	0.13	0.21			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.45	0.36	0.40				0.51	0.36	0.42
FEB	Cl_2 Demand												
	Cl_2 Dosage			1.03			0.12			1.25			0.22
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.23	0.10	0.18				0.31	0.13	0.22			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.47	0.32	0.40				0.49	0.37	0.39
MAR	Cl_2 Demand												
	Cl_2 Dosage			1.05			0.20			1.37			0.23
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.37	0.11	0.19				0.48	0.16	0.24			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.66	0.35	0.44				0.72	0.36	0.46

TABLE 3.0 (cont'd.) (mg/L)

		1986						1985					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			1.22			0.21			1.39			0.22
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.25	0.11	0.17				0.30	0.11	0.20			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.52	0.33	0.40				0.47	0.36	0.42
MAY	Cl_2 Demand												
	Cl_2 Dosage			1.23			0.19			1.45			0.23
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.48	0.10	0.19				0.23	0.12	0.18			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.64	0.32	0.41				0.45	0.34	0.41
JUN	Cl_2 Demand												
	Cl_2 Dosage			1.33			0.22			1.72			0.26
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.23	0.10	0.14				0.23	0.09	0.17			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.46	0.35	0.39				0.46	0.35	0.42

TABLE 3.0 (cont'd.) (mg/L)

		1986						1985					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			2.14			0.29			1.59			0.24
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.14	0.04	0.10				0.21	0.11	0.16			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.43	0.35	0.38				0.47	0.32	0.41
AUG	Cl_2 Demand												
	Cl_2 Dosage			1.82			0.20			1.94			0.34
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.11	0.05	0.08				0.24	0.08	0.12			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.35	0.29	0.32				0.46	0.37	0.41
SEP	Cl_2 Demand												
	Cl_2 Dosage			1.44			0.28			2.20			0.25
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.09	0.04	0.06				0.23	0.07	0.17			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.36	0.29	0.32				0.50	0.35	0.42

TABLE 3.0 (cont'd.) (mg/L)

		1986						1985					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			1.72			0.25			1.54			0.21
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.12	0.05	0.08				0.25	0.11	0.19			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.42	0.32	0.35				0.48	0.35	0.41
NOV	Cl_2 Demand												
	Cl_2 Dosage									1.66			0.24
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.31	0.07	0.12				0.26	0.12	0.18			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.55	0.35	0.41				0.46	0.35	0.41
DEC	Cl_2 Demand												
	Cl_2 Dosage									1.18			0.14
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.32	0.14	0.18				0.28	0.16	0.22			
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.56	0.32	0.39				0.47	0.37	0.42

TABLE 3.1: DISINFECTION SUMMARY (mg/L)

MOE WPOS PROTOCOL

		1984						1983					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand												
	Cl_2 Dosage			0.95			0.15						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.26	0.14	0.20									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.45	0.36	0.40						
FEB	Cl_2 Demand												
	Cl_2 Dosage			1.32			0.27						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.33	0.11	0.18									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.54	0.33	0.41						
MAR	Cl_2 Demand												
	Cl_2 Dosage			1.39			0.28						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.27	0.10	0.17									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.52	0.19	0.40						

TABLE 3.1 (cont'd.) (mg/L)

		1984						1983					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand												
	Cl_2 Dosage			1.37			0.19						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.24	0.11	0.18									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.47	0.33	0.41						
MAY	Cl_2 Demand												
	Cl_2 Dosage			1.58			0.26						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.23	0.09	0.15									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.44	0.35	0.41						
JUN	Cl_2 Demand												
	Cl_2 Dosage			1.65			0.28						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.24	0.11	0.16									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.45	0.34	0.39						

TABLE 3.1 (cont'd.) (mg/L)

		1984						1983					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand												
	Cl_2 Dosage			1.77			0.23						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.21	0.11	0.16									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.44	0.37	0.40						
AUG	Cl_2 Demand												
	Cl_2 Dosage			2.13			0.29						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.24	0.05	0.12									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.45	0.32	0.38						
SEP	Cl_2 Demand												
	Cl_2 Dosage			2.05			0.26						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.20	0.08	0.13									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.45	0.36	0.42						

TABLE 3.1 (cont'd.) (mg/L)

		1984						1983					
		PRE-CHLORINATION			POST-CHLORINATION			PRE-CHLORINATION			POST-CHLORINATION		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand												
	Cl_2 Dosage			1.78			0.29						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.22	0.09	0.18									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.46	0.38	0.43						
NOV	Cl_2 Demand												
	Cl_2 Dosage			1.60			0.25						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.28	0.13	0.20									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.50	0.39	0.45						
DEC	Cl_2 Demand												
	Cl_2 Dosage			1.39			0.23						
	Ammonia												
	SO_2												
	Resid. Cl_2 Free	0.29	0.16	0.21									
	Resid. Cl_2 Comb.												
	Resid. Cl_2 Total				0.49	0.37	0.43						

TABLE 3.2: DISINFECTION PROFILE JANUARY 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.56			0.22									0.42
2		1.16			0.20									0.39
3		0.83			0.19									0.41
4		0.49			0.18									0.39
5		0.71			0.20									0.39
6		0.87			0.20									0.40
7		0.96			0.19									0.38
8		0.59			0.18									0.36
9		0.66			0.18									0.36
10		0.54			0.21									0.47
11		1.01			0.22									0.41
12		1.50			0.20									0.41
13		1.22			0.23									0.41
14		0.89			0.23									0.38
15		1.04			0.21									0.36

TABLE 3.2 (cont'd.) JANUARY 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.27			0.18									0.38
17		1.42			0.22									0.43
18		1.06			0.19									0.40
19		1.25			0.21									0.37
20		0.70			0.17									0.37
21		1.10			0.19									0.38
22		1.71			0.18									0.45
23		0.90			0.07									0.32
24		2.04			0.17									0.43
25		1.11			0.22									0.42
26		1.37			0.18									0.43
27		1.36			0.18									0.38
28		1.24			0.25									0.44
29		0.93			0.22									0.42
30		1.11			0.21									0.40
31		0.87			0.14									0.38

TABLE 3.2: DISINFECTION PROFILE FEBRUARY 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		0.79			0.17									0.36
2		0.61			0.15									0.37
3		0.73			0.16									0.36
4		1.10			0.17									0.40
5		1.04			0.15									0.38
6		1.00			0.19									0.38
7		1.25			0.19									0.42
8		1.04			0.17									0.44
9		1.28			0.12									0.36
10		1.25			0.22									0.44
11		0.95			0.21									0.39
12		0.94			0.19									0.39
13		1.77			0.18									0.40
14		0.75			0.21									0.39
15		0.65			0.12									0.36

TABLE 3.2 (cont'd.) FEBRUARY 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.00			0.13									0.40
17		0.87			0.23									0.45
18		1.13			0.21									0.43
19		0.95			0.22									0.39
20		1.14			0.19									0.37
21		0.91			0.19									0.40
22		1.16			0.20									0.44
23		0.56			0.19									0.41
24		1.34			0.17									0.39
25		1.12			0.18									0.42
26		1.36			0.13									0.39
27		1.56			0.10									0.32
28		1.10			0.22									0.47
29														
30														
31														

TABLE 3.2: DISINFECTION PROFILE MARCH 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.19			0.18									0.42
2		1.10			0.15									0.35
3		1.40			0.14									0.36
4		1.39			0.17									0.40
5		1.15			0.12									0.36
6		0.71			0.18									0.42
7		0.87			0.15									0.37
8		1.21			0.22									0.57
9		0.83			0.21									0.55
10		1.19			0.31									0.59
11		1.43			0.11									0.66
12		1.75			0.37									0.61
13		2.03			0.21									0.54
14		1.82			0.21									0.49
15		0.60			0.21									0.36

TABLE 3.2 (cont'd.) MARCH 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.88			0.17									0.40
17		1.21			0.19									0.41
18		1.30			0.16									0.42
19		1.63			0.14									0.37
20		1.16			0.18									0.36
21		1.32			0.14									0.41
22		1.55			0.22									0.39
23		1.40			0.27									0.55
24		1.10			0.23									0.49
25		0.53			0.24									0.49
26		0.88			0.14									0.37
27		1.30			0.14									0.37
28		1.18			0.17									0.41
29		1.16			0.19									0.39
30		1.27			0.16									0.40
31		0.68			0.21									0.41

TABLE 3.2: DISINFECTION PROFILE APRIL 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
			NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2		
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total
1		0.92			0.20									0.38
2		0.86			0.18									0.39
3		1.02			0.22									0.40
4		1.04			0.21									0.42
5		1.29			0.18									0.41
6		1.25			0.19									0.39
7		1.26			0.21									0.40
8		2.05			0.18									0.36
9		1.45			0.17									0.42
10		1.53			0.15									0.38
11		1.15			0.25									0.52
12		0.93			0.19									0.33
13		2.41			0.14									0.33
14		0.86			0.11									0.35
15		1.51			0.19									0.40

TABLE 3.2 (cont'd.) APRIL 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.39			0.17									0.41
17		1.92			0.13									0.42
18		1.62			0.24									0.46
19		1.56			0.15									0.37
20		1.01			0.18									0.36
21		0.51			0.18									0.40
22		1.18			0.23									0.43
23		1.04			0.14									0.36
24		1.50			0.13									0.37
25		1.38			0.14									0.41
26		1.35			0.11									0.39
27		1.70			0.12									0.40
28		1.30			0.15									0.40
29		0.75			0.19									0.39
30		1.42			0.16									0.38
31														

TABLE 3.2: DISINFECTION PROFILE MAY 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.41			0.13									0.36
2		1.73			0.16									0.41
3		2.07			0.16									0.39
4		1.10			0.48									0.64
5		0.51			0.38									0.56
6		0.71			0.10									0.32
7		1.98			0.16									0.40
8		1.99			0.19									0.43
9		1.59			0.20									0.44
10		1.62			0.25									0.41
11		1.48			0.21									0.45
12		1.14			0.23									0.42
13		1.09			0.18									0.38
14		1.38			0.17									0.39
15		1.28			0.18									0.38

TABLE 3.2 (cont'd.) MAY 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.58			0.14									0.36
17		1.37			0.21									0.46
18		0.96			0.17									0.40
19		1.46			0.13									0.38
20		2.40			0.25									0.51
21		2.28			0.17									0.35
22		1.65			0.17									0.42
23		1.63			0.16									0.38
24		1.50			0.20									0.43
25		1.07			0.17									0.40
26		1.25			0.16									0.41
27		1.66			0.15									0.42
28		1.43			0.15									0.35
29		1.00			0.16									0.37
30		0.96			0.13									0.37
31		2.30			0.18									0.39

TABLE 3.2: DISINFECTION PROFILE JUNE 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.74			0.16									0.37
2		1.87			0.16									0.38
3		1.91			0.10									0.36
4		2.70			0.23									0.45
5		1.13			0.14									0.37
6		1.78			0.21									0.41
7		1.34			0.18									0.43
8		1.59			0.13									0.38
9		1.96			0.16									0.40
10		1.17			0.13									0.35
11		1.52			0.13									0.38
12		1.71			0.14									0.39
13		1.64			0.15									0.39
14		2.03			0.14									0.38
15		2.16			0.15									0.39

TABLE 3.2 (cont'd.) JUNE 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.24			0.16									0.39
17		1.14			0.14									0.37
18		1.58			0.13									0.37
19		2.65			0.12									0.40
20		1.29			0.14									0.41
21		1.25			0.12									0.46
22		1.89			0.10									0.37
23		2.15			0.13									0.42
24		2.01			0.11									0.35
25		2.19			0.14									0.40
26		0.97			0.14									0.41
27		1.90			0.12									0.41
28		2.10			0.11									0.40
29		2.06			0.13									0.38
30		1.79			0.12									0.41
31														

TABLE 3.2: DISINFECTION PROFILE JULY 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.83			0.11									0.36
2		2.33			0.10									0.41
3		1.68			0.11									0.40
4		2.05			0.10									0.40
5		1.84			0.10									0.42
6		2.07			0.11									0.41
7		2.44			0.10									0.38
8		2.43			0.08									0.36
9		2.50			0.06									0.37
10		2.54			0.08									0.38
11		2.45			0.10									0.35
12		2.36			0.14									0.43
13		2.34			0.09									0.38
14		2.65			0.07									0.37
15		2.05			0.11									0.40

TABLE 3.2 (cont'd.) JULY 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.53			0.08									0.35
17		2.65			0.13									0.36
18		3.12			0.06									0.36
19		3.28			0.09									0.39
20		2.51			0.12									0.39
21		2.63			0.10									0.37
22		2.87			0.10									0.37
23		3.00			0.08									0.38
24		1.97			0.10									0.38
25		2.56			0.09									0.38
26		3.77			0.09									0.38
27		2.51			0.04									0.35
28		3.02			0.06									0.38
29		2.56			0.13									0.37
30		3.39			0.14									0.37
31		2.92			0.12									0.38

TABLE 3.2: DISINFECTION PROFILE AUGUST 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.82			0.10									0.34
2		2.67			0.09									0.34
3		3.24			0.08									0.33
4		2.88			0.08									0.33
5		1.97			0.07									0.30
6		2.36			0.07									0.31
7		2.06			0.07									0.30
8		2.44			0.06									0.29
9		1.94			0.06									0.30
10		2.58			0.05									0.32
11		1.91			0.07									0.32
12		2.17			0.06									0.31
13		2.35			0.07									0.32
14		2.65			0.08									0.31
15		1.97			0.11									0.33

TABLE 3.2 (cont'd.) AUGUST 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.60			0.07									0.32
17		1.51			0.08									0.30
18		1.49			0.06									0.32
19		1.67			0.07									0.31
20		2.13			0.09									0.34
21		1.60			0.10									0.33
22		1.89			0.05									0.31
23		3.02			0.08									0.32
24		3.09			0.09									0.30
25		2.12			0.09									0.33
26		2.86			0.09									0.31
27		2.77			0.07									0.33
28		2.99			0.10									0.32
29		1.80			0.07									0.33
30		1.66			0.09									0.35
31		2.28			0.09									0.34

TABLE 3.2: DISINFECTION PROFILE SEPTEMBER 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.37			0.09									0.29
2		1.76			0.06									0.35
3		1.52			0.06									0.32
4		1.54			0.06									0.32
5		1.86			0.04									0.31
6		1.82			0.07									0.32
7		2.32			0.07									0.30
8		1.71			0.08									0.31
9		2.20			0.06									0.32
10		1.91			0.07									0.33
11		2.95			0.05									0.33
12		2.09			0.06									0.33
13		1.76			0.06									0.33
14		1.22			0.05									0.31
15		2.21			0.06									0.36

TABLE 3.2 (cont'd.) SEPTEMBER 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.11			0.07									0.30
17		1.82			0.06									0.32
18		1.39			0.07									0.33
19		1.76			0.06									0.32
20		2.07			0.07									0.34
21		1.75			0.06									0.32
22		2.13			0.06									0.33
23		1.73			0.04									0.29
24		2.00			0.06									0.31
25		1.68			0.06									0.31
26		1.78			0.07									0.33
27		1.81			0.06									0.32
28		1.58			0.06									0.31
29		1.92			0.07									0.36
30		2.08			0.06									0.31
31														

TABLE 3.2: DISINFECTION PROFILE OCTOBER 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.81			0.05									0.32
2		2.34			0.08									0.35
3		2.16			0.05									0.37
4		2.36			0.08									0.35
5		2.29			0.09									0.33
6		2.33			0.08									0.33
7		2.46			0.06									0.32
8		2.41			0.07									0.34
9		2.51			0.10									0.42
10		1.54			0.11									0.40
11		1.68			0.11									0.36
12		1.95			0.08									0.35
13		1.62			0.10									0.36
14		1.45			0.08									0.34
15		1.62			0.12									0.35

TABLE 3.2 (cont'd.) OCTOBER 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.51			0.10									0.35
17		1.97			0.07									0.34
18		2.29			0.10									0.36
19		2.11			0.08									0.32
20		2.14			0.08									0.32
21		1.90			0.09									0.35
22		2.37			0.07									0.36
23		2.41			0.10									0.35
24		1.98			0.11									0.33
25		2.28			0.11									0.37
26		1.92			0.08									0.33
27		0.79			0.11									0.34
28		1.67			0.09									0.36
29		2.00			0.10									0.37
30		1.93			0.09									0.38
31		2.66			0.10									0.38

TABLE 3.2: DISINFECTION PROFILE NOVEMBER 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.67			0.10									0.35
2		2.07			0.08									0.36
3		1.68			0.07									0.36
4		1.18			0.10									0.37
5		1.57			0.08									0.35
6		2.34			0.08									0.36
7		1.89			0.08									0.36
8		1.69			0.09									0.36
9		1.98			0.08									0.39
10		1.71			0.10									0.39
11		1.99			0.10									0.39
12		1.55			0.09									0.38
13		2.03			0.13									0.40
14		2.06			0.10									0.39
15		2.69			0.09									0.38

TABLE 3.2 (cont'd.) NOVEMBER 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.96			0.10									0.38
17		1.95			0.10									0.38
18		2.27			0.09									0.40
19		1.43			0.15									0.39
20		1.87			0.15									0.40
21		1.59			0.14									0.48
22		1.43			0.31									0.55
23		1.44			0.25									0.51
24		1.32			0.27									0.54
25		1.92			0.08									0.46
26		2.25			0.06									0.52
27		1.58			0.15									0.39
28		1.79			0.19									0.41
29		1.39			0.16									0.43
30		1.54			0.13									0.38
31														

TABLE 3.2: DISINFECTION PROFILE DECEMBER 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.04			0.16									0.41
2		1.92			0.19									0.39
3		1.77			0.15									0.44
4		2.41			0.20									0.41
5		1.32			0.20									0.37
6		1.56			0.15									0.39
7		1.39			0.18									0.37
8		0.96			0.15									0.39
9		1.20			0.17									0.35
10		1.32			0.20									0.39
11		1.20			0.18									0.38
12		1.23			0.18									0.39
13		1.92			0.16									0.41
14		1.70			0.14									0.39
15		1.46			0.24									0.44

TABLE 3.2 (cont'd.) DECEMBER 1986 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.13			0.15									0.40
17		1.59			0.14									0.37
18		1.48			0.21									0.42
19		1.01			0.20									0.39
20		1.02			0.17									0.36
21		0.83			0.17									0.32
22		1.09			0.19									0.36
23		1.03			0.17									0.33
24		1.03			0.16									0.38
25		1.30			0.16									0.40
26		1.13			0.16									0.37
27		2.41			0.25									0.43
28		2.35			0.32									0.56
29		1.46			0.19									0.41
30		1.15			0.23									0.43
31		0.92			0.17									0.38

TABLE 3.2: DISINFECTION PROFILE JANUARY 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.27			0.19									0.37
2		1.77			0.19									0.41
3		2.41			0.18									0.42
4		2.22			0.13									0.37
5		2.19			0.15									0.41
6		1.83			0.17									0.40
7		2.28			0.19									0.43
8		1.56			0.21									0.43
9		2.21			0.24									0.45
10		2.00			0.25									0.46
11		2.14			0.26									0.47
12		2.15			0.20									0.45
13		2.00			0.17									0.43
14		2.16			0.19									0.36
15		2.33			0.21									0.44

TABLE 3.2 (cont'd.) JANUARY 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
			NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2		
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total
16		1.89			0.29									0.51
17		2.24			0.25									0.45
18		1.32			0.27									0.42
19		1.96			0.25									0.41
20		1.32			0.19									0.39
21		1.45			0.26									0.44
22		1.13			0.29									0.45
23		1.53			0.20									0.42
24		1.63			0.20									0.41
25		1.83			0.18									0.39
26		1.53			0.26									0.44
27		1.72			0.19									0.41
28		1.72			0.22									0.42
29		1.75			0.19									0.42
30		1.39			0.23									0.43
31		1.69			0.21									0.42

TABLE 3.2: DISINFECTION PROFILE FEBRUARY 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.63			0.25									0.47
2		1.50			0.27									0.45
3		1.33			0.22									0.44
4		1.37			0.23									0.43
5		1.68			0.23									0.45
6		1.21			0.25									0.41
7		1.21			0.20									0.40
8		1.15			0.20									0.42
9		1.73			0.13									0.37
10		1.40			0.19									0.42
11		1.58			0.17									0.41
12		1.90			0.17									0.41
13		1.59			0.22									0.41
14		2.31			0.21									0.47
15		1.48			0.31									0.49

TABLE 3.2 (cont'd.) FEBRUARY 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.59			0.28									0.48
17		1.37			0.30									0.43
18		1.52			0.29									0.48
19		1.52			0.28									0.48
20		1.53			0.21									0.43
21		2.08			0.19									0.41
22		1.47			0.18									0.40
23		2.27			0.19									0.37
24		2.96			0.22									0.47
25		2.05			0.21									0.42
26		2.23			0.14									0.41
27		1.64			0.22									0.45
28		2.13			0.15									0.37
29														
30														
31														

TABLE 3.2: DISINFECTION PROFILE MARCH 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.20			0.17									0.42
2		1.24			0.48									0.58
3		1.14			0.31									0.46
4		1.02			0.31									0.45
5		1.84			0.18									0.36
6		1.86			0.25									0.48
7		1.60			0.24									0.51
8		1.51			0.24									0.48
9		1.63			0.19									0.38
10		1.82			0.27									0.42
11		2.09			0.19									0.38
12		2.50			0.22									0.46
13		1.54			0.31									0.49
14		1.39			0.28									0.49
15		1.58			0.25									0.45

TABLE 3.2 (cont'd.) MARCH 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.37			0.30									0.58
17		0.91			0.26									0.64
18		1.36			0.21									0.72
19		1.30			0.18									0.40
20		1.64			0.23									0.44
21		1.51			0.18									0.37
22		1.85			0.22									0.36
23		1.76			0.16									0.38
24		1.65			0.22									0.46
25		2.02			0.21									0.44
26		1.38			0.18									0.41
27		1.74			0.19									0.42
28		1.64			0.19									0.45
29		3.18			0.29									0.53
30		1.63			0.18									0.39
31		1.50			0.32									0.45

TABLE 3.2: DISINFECTION PROFILE APRIL 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.74			0.16									0.43
2		1.81			0.22									0.45
3		1.98			0.16									0.41
4		1.46			0.16									0.38
5		1.92			0.20									0.36
6		2.92			0.20									0.45
7		2.04			0.17									0.44
8		2.32			0.16									0.39
9		1.97			0.18									0.41
10		1.29			0.19									0.38
11		1.23			0.21									0.45
12		1.54			0.23									0.43
13		1.72			0.26									0.44
14		1.62			0.26									0.44
15		1.59			0.30									0.47

TABLE 3.2 (cont'd.) APRIL 1985 (mg/L)

DATE	PRE- & POST- Cl_2 Dem.	PRE- & POST- Cl_2 Dos.	PRE-CHLORINATION NH_3	PRE-CHLORINATION SO_2	PRE-CHLORINATION RESIDUAL Cl_2 Free	PRE-CHLORINATION RESIDUAL Cl_2 Comb.	PRE-CHLORINATION RESIDUAL Cl_2 Total	POST-CHLORINATION Cl_2 Dem.	POST-CHLORINATION Cl_2 Dos.	POST-CHLORINATION NH_3	POST-CHLORINATION SO_2	POST-CHLORINATION RESIDUAL Cl_2 Free	POST-CHLORINATION RESIDUAL Cl_2 Comb.	POST-CHLORINATION RESIDUAL Cl_2 Total
16		1.43			0.30									0.47
17		1.23			0.24									0.43
18		1.32			0.26									0.42
19		1.46			0.23									0.40
20		1.31			0.25									0.43
21		1.18			0.24									0.46
22		1.51			0.20									0.43
23		1.57			0.24									0.45
24		1.24			0.20									0.39
25		1.72			0.14									0.38
26		1.87			0.19									0.44
27		1.25			0.16									0.39
28		1.04			0.14									0.36
29		1.72			0.11									0.42
30		1.65			0.16									0.41
31														

TABLE 3.2: DISINFECTION PROFILE MAY 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.81			0.14									0.40
2		1.66			0.13									0.40
3		1.63			0.18									0.45
4		1.81			0.17									0.40
5		1.66			0.19									0.43
6		1.53			0.18									0.41
7		1.59			0.14									0.37
8		1.93			0.15									0.40
9		2.02			0.16									0.42
10		1.77			0.20									0.42
11		1.53			0.18									0.45
12		1.04			0.20									0.42
13		1.45			0.20									0.43
14		1.59			0.17									0.39
15		1.93			0.19									0.42

TABLE 3.2 (cont'd.) MAY 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
			NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2		
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total
16		1.43			0.23									0.44
17		1.22			0.21									0.38
18		0.91			0.18									0.41
19		1.84			0.16									0.40
20		2.52			0.20									0.40
21		2.42			0.13									0.38
22		2.79			0.18									0.43
23		2.58			0.19									0.45
24		1.94			0.12									0.41
25		1.59			0.19									0.38
26		1.70			0.21									0.41
27		1.85			0.21									0.41
28		1.23			0.15									0.42
29		1.15			0.20									0.41
30		1.22			0.22									0.40
31		1.74			0.16									0.34

TABLE 3.2: DISINFECTION PROFILE JUNE 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.43			0.18									0.42
2		2.22			0.18									0.40
3		2.12			0.17									0.40
4		1.94			0.18									0.43
5		1.71			0.20									0.41
6		2.13			0.23									0.44
7		3.17			0.23									0.44
8		1.35			0.22									0.45
9		0.92			0.15									0.39
10		1.80			0.11									0.34
11		2.40			0.17									0.41
12		3.05			0.15									0.44
13		2.86			0.14									0.39
14		1.70			0.21									0.43
15		1.27			0.13									0.41

TABLE 3.2 (cont'd.) JUNE 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.72			0.16									0.42
17		2.28			0.14									0.42
18		2.02			0.10									0.39
19		2.06			0.09									0.35
20		1.85			0.09									0.42
21		2.50			0.18									0.43
22		2.05			0.17									0.42
23		2.20			0.20									0.46
24		2.66			0.16									0.45
25		2.07			0.19									0.46
26		1.68			0.25									0.46
27		2.05			0.18									0.44
28		1.75			0.18									0.44
29		1.67			0.14									0.40
30		1.53			0.18									0.44
31														

TABLE 3.2: DISINFECTION PROFILE JULY 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.08			0.21									0.42
2		2.13			0.11									0.32
3		2.23			0.13									0.40
4		2.13			0.14									0.45
5		1.92			0.16									0.46
6		2.71			0.19									0.41
7		1.45			0.19									0.41
8		1.67			0.18									0.42
9		2.15			0.16									0.40
10		2.60			0.16									0.40
11		2.30			0.15									0.41
12		2.38			0.11									0.41
13		1.99			0.12									0.40
14		2.74			0.16									0.43
15		2.41			0.11									0.47

TABLE 3.2 (cont'd.) JULY 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.63			0.11									0.41
17		1.01			0.12									0.41
18		4.17			0.11									0.41
19		2.69			0.17									0.45
20		2.81			0.16									0.40
21		2.56			0.17									0.41
22		3.18			0.15									0.40
23		2.07			0.16									0.40
24		2.30			0.18									0.43
25		1.49			0.19									0.40
26		1.45			0.16									0.41
27		1.53			0.19									0.41
28		1.65			0.18									0.36
29		2.02			0.15									0.38
30		1.78			0.18									0.39
31		2.18			0.16									0.42

TABLE 3.2: DISINFECTION PROFILE AUGUST 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.11			0.19									0.45
2		1.68			0.17									0.43
3		1.23			0.12									0.40
4		1.74			0.12									0.38
5		3.08			0.09									0.42
6		2.37			0.13									0.37
7		2.38			0.08									0.35
8		2.43			0.08									0.37
9		2.14			0.13									0.41
10		1.76			0.10									0.43
11		1.53			0.12									0.43
12		2.17			0.09									0.40
13		2.90			0.11									0.41
14		2.81			0.11									0.42
15		3.07			0.09									0.40

TABLE 3.2 (cont'd.) AUGUST 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		3.49			0.09									0.40
17		2.26			0.08									0.38
18		1.43			0.11									0.45
19		3.40			0.08									0.41
20		3.33			0.10									0.44
21		3.45			0.10									0.46
22		2.49			0.09									0.43
23		2.35			0.24									0.45
24		3.31			0.14									0.42
25		3.10			0.16									0.44
26		1.49			0.21									0.40
27		1.60			0.18									0.43
28		2.84			0.14									0.40
29		3.03			0.14									0.43
30		2.77			0.11									0.39
31		3.28			0.08									0.40

TABLE 3.2: DISINFECTION PROFILE SEPTEMBER 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.87			0.07									0.40
2		3.68			0.13									0.45
3		2.53			0.16									0.42
4		2.15			0.14									0.44
5		2.61			0.19									0.46
6		3.17			0.17									0.42
7		2.98			0.13									0.36
8		3.20			0.11									0.37
9		3.40			0.15									0.46
10		3.09			0.14									0.38
11		3.07			0.13									0.35
12		2.34			0.13									0.44
13		3.32			0.17									0.48
14		2.18			0.14									0.40
15		3.15			0.10									0.41

TABLE 3.2 (cont'd.) SEPTEMBER 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.52			0.20									0.42
17		1.91			0.14									0.41
18		2.57			0.19									0.50
19		1.84			0.19									0.41
20		1.30			0.18									0.38
21		2.10			0.14									0.39
22		2.52			0.21									0.42
23		2.57			0.21									0.41
24		2.53			0.17									0.36
25		2.52			0.21									0.44
26		2.46			0.21									0.45
27		1.89			0.21									0.41
28		1.31			0.20									0.43
29		1.49			0.23									0.47
30		2.42			0.23									0.46
31														

TABLE 3.2: DISINFECTION PROFILE OCTOBER 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.32			0.18									0.41
2		2.21			0.20									0.43
3		1.72			0.16									0.44
4		1.79			0.15									0.41
5		2.29			0.15									0.42
6		2.96			0.20									0.45
7		2.27			0.20									0.48
8		0.69			0.19									0.45
9		2.02			0.22									0.44
10		1.30			0.25									0.42
11		1.91			0.21									0.43
12		1.49			0.22									0.40
13		1.59			0.20									0.37
14		1.89			0.20									0.41
15		1.48			0.19									0.39

TABLE 3.2 (cont'd.) OCTOBER 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.68			0.22									0.44
17		1.22			0.19									0.39
18		1.21			0.14									0.38
19		1.45			0.11									0.35
20		2.58			0.17									0.38
21		1.05			0.19									0.40
22		1.29			0.22									0.42
23		1.13			0.18									0.41
24		1.89			0.19									0.43
25		1.80			0.18									0.38
26		1.78			0.17									0.38
27		1.57			0.16									0.42
28		1.29			0.18									0.44
29		1.62			0.23									0.43
30		1.98			0.25									0.45
31		1.83			0.18									0.38

TABLE 3.2: DISINFECTION PROFILE NOVEMBER 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.73			0.20									0.43
2		1.86			0.20									0.41
3		2.75			0.20									0.41
4		1.93			0.26									0.46
5		2.89			0.24									0.41
6		1.14			0.20									0.45
7		3.08			0.20									0.42
8		1.95			0.15									0.42
9		2.18			0.20									0.41
10		2.24			0.23									0.46
11		2.42			0.15									0.35
12		1.49			0.19									0.40
13		1.68			0.17									0.38
14		1.76			0.16									0.40
15		2.07			0.16									0.39

TABLE 3.2 (cont'd.) NOVEMBER 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.32			0.18									0.39
17		1.37			0.16									0.37
18		1.30			0.23									0.44
19		1.74			0.17									0.40
20		2.95			0.15									0.39
21		1.87			0.15									0.40
22		1.47			0.12									0.36
23		1.08			0.23									0.45
24		2.46			0.17									0.42
25		1.43			0.13									0.38
26		1.77			0.12									0.36
27		1.52			0.19									0.42
28		0.87			0.22									0.43
29		0.96			0.14									0.36
30		2.11			0.16									0.40
31														

TABLE 3.2: DISINFECTION PROFILE DECEMBER 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.27			0.17									0.43
2		1.65			0.19									0.40
3		1.44			0.19									0.43
4		1.82			0.16									0.41
5		1.92			0.19									0.40
6		1.95			0.27									0.45
7		1.54			0.28									0.45
8		1.39			0.23									0.39
9		1.32			0.22									0.40
10		0.91			0.19									0.38
11		1.27			0.21									0.41
12		1.23			0.21									0.42
13		1.22			0.23									0.43
14		1.11			0.28									0.41
15		0.99			0.28									0.40

TABLE 3.2 (cont'd.) DECEMBER 1985 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		0.54			0.20									0.37
17		0.63			0.24									0.47
18		0.76			0.28									0.45
19		1.35			0.24									0.44
20		0.86			0.19									0.40
21		1.13			0.28									0.46
22		1.15			0.21									0.44
23		0.96			0.21									0.45
24		1.18			0.25									0.43
25		1.15			0.20									0.40
26		0.82			0.27									0.40
27		1.03			0.22									0.37
28		1.38			0.24									0.41
29		1.25			0.18									0.40
30		1.29			0.21									0.41
31		1.16			0.22									0.41

TABLE 3.2: DISINFECTION PROFILE JANUARY 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		0.93			0.19									0.41
2		1.30			0.19									0.41
3		1.23			0.19									0.39
4		1.09			0.25									0.44
5		0.91			0.25									0.44
6		0.82			0.15									0.36
7		1.31			0.22									0.42
8		1.27			0.23									0.41
9		1.10			0.25									0.38
10		1.15			0.22									0.38
11		1.17			0.22									0.44
12		1.27			0.20									0.38
13		0.92			0.17									0.38
14		1.52			0.20									0.38
15		1.36			0.22									0.45

TABLE 3.2 (cont'd.) JANUARY 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.30			0.18									0.41
17		1.44			0.14									0.37
18		0.91			0.16									0.38
19		1.39			0.26									0.43
20		0.90			0.17									0.40
21		1.33			0.16									0.41
22		1.20			0.17									0.40
23		0.73			0.17									0.40
24		1.59			0.14									0.41
25		1.34			0.21									0.41
26		1.34			0.20									0.38
27		1.48			0.15									0.39
28		1.32			0.22									0.45
29		1.48			0.23									0.40
30		1.38			0.18									0.42
31		0.92			0.20									0.41

TABLE 3.2: DISINFECTION PROFILE FEBRUARY 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.18			0.18									0.40
2		1.07			0.15									0.39
3		1.20			0.15									0.38
4		0.33			0.14									0.33
5		1.84			0.15									0.38
6		0.87			0.19									0.42
7		1.26			0.18									0.38
8		1.11			0.20									0.43
9		1.17			0.18									0.40
10		1.08			0.24									0.43
11		1.62			0.15									0.37
12		1.00			0.17									0.38
13		1.35			0.17									0.35
14		2.62			0.18									0.54
15		2.51			0.22									0.41

TABLE 3.2 (cont'd.) FEBRUARY 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.84			0.20									0.45
17		2.55			0.33									0.47
18		2.01			0.18									0.42
19		1.71			0.16									0.41
20		1.06			0.25									0.47
21		1.19			0.15									0.39
22		1.57			0.16									0.40
23		1.52			0.13									0.39
24		1.75			0.08									0.37
25		1.99			0.11									0.38
26		1.96			0.23									0.49
27		1.27			0.16									0.45
28		1.79			0.17									0.40
29		3.03			0.21									0.44
30														
31														

TABLE 3.2: DISINFECTION PROFILE MARCH 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.52			0.18									0.43
2		1.60			0.20									0.52
3		1.62			0.22									0.44
4		1.21			0.22									0.42
5		1.15			0.18									0.42
6		1.34			0.27									0.42
7		1.48			0.14									0.37
8		1.74			0.15									0.32
9		1.70			0.13									0.19
10		2.12			0.10									0.41
11		2.06			0.19									0.42
12		1.73			0.19									0.40
13		2.10			0.18									0.39
14		1.50			0.14									0.34
15		2.46			0.19									0.41

TABLE 3.2 (cont'd.) MARCH 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.12			0.15									0.42
17		1.31			0.22									0.43
18		1.94			0.20									0.42
19		1.42			0.20									0.42
20		2.08			0.17									0.41
21		1.75			0.10									0.41
22		1.49			0.16									0.39
23		1.88			0.18									0.46
24		1.79			0.16									0.37
25		2.20			0.15									0.40
26		2.23			0.16									0.41
27		2.14			0.18									0.39
28		1.65			0.13									0.42
29		2.54			0.11									0.39
30		2.44			0.15									0.42
31		2.20			0.18									0.43

TABLE 3.2: DISINFECTION PROFILE APRIL 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.95			0.15									0.40
2		1.51			0.19									0.43
3		1.60			0.15									0.38
4		1.84			0.15									0.36
5		2.33			0.11									0.38
6		2.27			0.27									0.47
7		2.01			0.18									0.44
8		1.90			0.16									0.42
9		2.53			0.17									0.47
10		2.05			0.17									0.40
11		1.65			0.14									0.40
12		1.92			0.19									0.43
13		1.80			0.21									0.43
14		1.60			0.24									0.46
15		1.91			0.19									0.41

TABLE 3.2 (cont'd.) APRIL 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.48			0.21									0.37
17		1.35			0.20									0.41
18		2.06			0.15									0.37
19		1.55			0.20									0.41
20		1.53			0.16									0.40
21		1.58			0.21									0.43
22		1.50			0.19									0.42
23		1.51			0.18									0.41
24		1.70			0.18									0.39
25		1.20			0.17									0.40
26		1.66			0.20									0.43
27		1.58			0.16									0.33
28		1.56			0.19									0.38
29		1.89			0.20									0.44
30		1.64			0.14									0.38
31														

TABLE 3.2: DISINFECTION PROFILE MAY 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.61			0.11									0.36
2		1.62			0.12									0.38
3		1.49			0.18									0.40
4		1.94			0.22									0.42
5		1.19			0.22									0.43
6		1.59			0.16									0.41
7		1.51			0.21									0.41
8		1.91			0.18									0.40
9		1.52			0.18									0.42
10		2.20			0.10									0.39
11		2.02			0.12									0.36
12		1.63			0.10									0.35
13		2.23			0.12									0.41
14		1.98			0.09									0.39
15		2.23			0.15									0.41

TABLE 3.2 (cont'd.) MAY 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.12			0.20									0.42
17		1.51			0.23									0.44
18		1.71			0.17									0.44
19		2.00			0.12									0.39
20		2.47			0.09									0.39
21		2.74			0.12									0.38
22		2.05			0.13									0.44
23		2.61			0.14									0.42
24		2.35			0.19									0.42
25		1.86			0.12									0.41
26		1.97			0.21									0.44
27		2.07			0.12									0.41
28		1.86			0.17									0.42
29		1.87			0.19									0.93
30		1.58			0.15									0.42
31		1.70			0.15									0.39

TABLE 3.2: DISINFECTION PROFILE JUNE 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.96			0.14									0.38
2		1.39			0.15									0.38
3		1.47			0.14									0.35
4		1.48			0.15									0.34
5		1.52			0.15									0.38
6		1.97			0.15									0.37
7		2.36			0.13									0.39
8		1.82			0.18									0.44
9		1.72			0.23									0.42
10		1.92			0.18									0.38
11		1.97			0.24									0.43
12		2.33			0.22									0.45
13		2.08			0.22									0.43
14		2.37			0.17									0.42
15		2.26			0.15									0.41

TABLE 3.2 (cont'd.) JUNE 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.00			0.15									0.38
17		2.30			0.16									0.41
18		0.80			0.19									0.40
19		2.02			0.14									0.39
20		2.02			0.14									0.39
21		2.49			0.12									0.36
22		2.11			0.16									0.40
23		2.16			0.13									0.38
24		2.66			0.11									0.36
25		2.91			0.07									0.36
26		3.03			0.16									0.42
27		2.17			0.14									0.39
28		2.57			0.16									0.42
29		2.51			0.18									0.41
30		1.36			0.15									0.38
31														

TABLE 5.2. DISINFECTION PROFILE

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.80			0.15									0.38
2		1.81			0.19									0.41
3		2.00			0.13									0.38
4		2.46			0.17									0.40
5		2.01			0.19									0.41
6		1.99			0.19									0.42
7		2.24			0.18									0.40
8		2.27			0.16									0.40
9		1.92			0.19									0.43
10		1.95			0.17									0.37
11		2.31			0.17									0.39
12		1.75			0.14									0.39
13		1.79			0.15									0.43
14		2.42			0.21									0.39
15		2.64			0.16									0.42

TABLE 3.2 (cont'd.) JULY 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.35			0.16									0.39
17		1.83			0.13									0.39
18		2.38			0.11									0.37
19		2.41			0.13									0.40
20		2.09			0.13									0.38
21		2.21			0.16									0.41
22		2.15			0.14									0.40
23		2.04			0.15									0.41
24		2.55			0.16									0.40
25		2.20			0.19									0.44
26		2.19			0.16									0.39
27		2.54			0.17									0.40
28		2.33			0.16									0.39
29		2.13			0.16									0.39
30		2.03			0.17									0.43
31		1.86			0.15									0.38

TABLE 3.2: DISINFECTION PROFILE AUGUST 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.76			0.13									0.38
2		3.16			0.18									0.39
3		2.14			0.24									0.39
4		1.61			0.18									0.38
5		2.02			0.16									0.37
6		2.07			0.18									0.36
7		2.61			0.11									0.32
8		1.88			0.13									0.35
9		2.33			0.14									0.40
10		2.96			0.12									0.37
11		2.57			0.12									0.37
12		3.22			0.13									0.37
13		1.89			0.12									0.35
14		2.81			0.11									0.33
15		3.05			0.13									0.37

TABLE 3.2 (cont'd.) AUGUST 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		2.61			0.05									0.33
17		3.09			0.07									0.44
18		2.76			0.08									0.45
19		3.93			0.14									0.42
20		4.83			0.13									0.43
21		3.24			0.10									0.42
22		2.82			0.07									0.36
23		2.75			0.07									0.38
24		2.65			0.09									0.38
25		2.55			0.12									0.37
26		2.33			0.13									0.38
27		2.45			0.10									0.37
28		2.83			0.10									0.39
29		3.48			0.11									0.40
30		2.85			0.12									0.40
31		3.13			0.11									0.39

TABLE 3.2: DISINFECTION PROFILE SEPTEMBER 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		4.22			0.08									0.36
2		3.60			0.17									0.41
3		2.40			0.20									0.44
4		2.42			0.18									0.42
5		2.97			0.17									0.41
6		2.69			0.17									0.40
7		2.79			0.19									0.44
8		2.56			0.14									0.42
9		2.56			0.14									0.38
10		2.55			0.18									0.41
11		2.28			0.16									0.40
12		2.14			0.13									0.43
13		2.20			0.12									0.41
14		2.69			0.11									0.44
15		2.06			0.13									0.41

TABLE 3.2 (cont'd.) SEPTEMBER 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		3.03			0.13									0.45
17		2.63			0.08									0.42
18		2.96			0.11									0.44
19		2.71			0.12									0.43
20		2.12			0.08									0.40
21		2.94			0.10									0.43
22		2.57			0.14									0.45
23		3.24			0.12									0.42
24		2.52			0.12									0.42
25		2.30			0.08									0.42
26		2.43			0.13									0.41
27		2.30			0.17									0.44
28		2.49			0.12									0.39
29		2.36			0.13									0.39
30		2.52			0.11									0.40
31														

TABLE 3.2: DISINFECTION PROFILE OCTOBER 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.50			0.14									0.44
2		2.40			0.14									0.44
3		2.32			0.16									0.45
4		2.03			0.20									0.44
5		1.95			0.18									0.43
6		1.98			0.11									0.39
7		2.20			0.20									0.44
8		2.26			0.21									0.45
9		1.89			0.22									0.42
10		1.47			0.19									0.38
11		2.11			0.18									0.39
12		2.21			0.18									0.45
13		2.11			0.22									0.45
14		2.02			0.16									0.41
15		2.05			0.18									0.42

TABLE 3.2 (cont'd.) OCTOBER 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.69			0.21									0.45
17		2.14			0.18									0.40
18		1.61			0.18									0.42
19		2.32			0.09									0.40
20		1.92			0.12									0.46
21		2.06			0.14									0.42
22		2.20			0.15									0.42
23		1.79			0.19									0.45
24		2.51			0.19									0.45
25		2.05			0.22									0.45
26		2.07			0.20									0.42
27		2.13			0.21									0.43
28		2.88			0.18									0.45
29		1.79			0.18									2.46
30		2.40			0.17									0.45
31		2.11			0.17									0.45

TABLE 3.2: DISINFECTION PROFILE NOVEMBER 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		2.19			0.16									0.44
2		2.48			0.17									0.44
3		2.29			0.21									0.42
4		2.06			0.20									0.42
5		2.00			0.21									0.43
6		2.39			0.21									0.44
7		2.22			0.17									0.39
8		2.66			0.16									0.43
9		2.84			0.13									0.46
10		2.12			0.21									0.44
11		2.10			0.16									0.41
12		2.22			0.18									0.49
13		1.86			0.22									0.46
14		1.86			0.19									0.47
15		1.75			0.22									0.45

TABLE 3.2 (cont'd.) NOVEMBER 1984 (mg/L)

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
16		1.94			0.27									0.45
17		1.64			0.17									0.42
18		1.97			0.18									0.45
19		1.90			0.21									0.48
20		1.99			0.22									0.47
21		1.39			0.21									0.49
22		1.54			0.28									0.47
23		2.25			0.28									0.50
24		1.71			0.26									0.49
25		2.03			0.22									0.45
26		1.27			0.19									0.43
27		1.20			0.22									0.45
28		1.58			0.19									0.42
29		1.28			0.25									0.46
30		1.39			0.15									0.40
31														

TABLE 3.2: DISINFECTION PROFILE DECEMBER 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PRE- & POST- Cl_2		PRE-CHLORINATION					POST-CHLORINATION						
					RESIDUAL Cl_2			Cl_2				RESIDUAL Cl_2		
	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total	Dem.	Dos.	NH_3	SO_2	Free	Comb.	Total
1		1.23			0.20									0.42
2		1.34			0.20									0.42
3		1.57			0.18									0.42
4		1.39			0.23									0.43
5		1.52			0.22									0.43
6		2.21			0.19									0.46
7		1.59			0.22									0.49
8		1.21			0.16									0.48
9		1.77			0.18									0.42
10		1.38			0.22									0.46
11		1.64			0.20									0.42
12		1.50			0.24									0.43
13		1.54			0.19									0.41
14		1.40			0.22									0.43
15		1.49			0.18									0.41

TABLE 4.0: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION SUMMARY (mg/L)

MOE WPOS PROTOCOL

		1986			1985			1984			1983		
		MIN.	MAX.	AVG.	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.
JAN	PAC (1)	0.33	0.99	0.76	0	0	0	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
FEB	PAC	0	0	0	0	0	0	1.23	1.23	1.23			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
MAR	PAC	0.29	0.72	0.46	1.36	1.36	1.36	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
APR	PAC	0	0	0	0.83	1.08	0.97	1.11	1.11	1.11			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
MAY	PAC	0.40	1.05	0.66	0.50	1.09	0.85	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
JUN	PAC	0.92	0.92	0.92	0.50	0.66	0.58	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												

(1) Powdered Activated Carbon

TABLE 4.0 (cont'd.) (mg/L)

		1986			1985			1984			1983		
		MIN.	MAX.	AVG.	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.
JUL	PAC (1)	0.37	1.15	0.80	0.68	0.69	0.68	.53	.99	0.76			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
AUG	PAC	0.38	1.89	0.87	0.40	1.59	0.68	0.67	1.94	1.18			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
SEP	PAC	0.38	1.04	0.64	0.55	1.25	0.89	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
OCT	PAC	0	0	0	0	0	0	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
NOV	PAC	0	0	0	0.51	1.23	0.77	0	0	0			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												
DEC	PAC	0	0	0	0	0	0	0.68	1.97	1.41			
	$KMnO_4$												
	Lime												
	Soda Ash												
	F Dos.												
	F Res.												

(1) Powdered Activated Carbon

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE

JANUARY 1986

MOE WPOS PROTOCOL

DATE	PAC(1)	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

(1) Powdered Activated Carbon

TABLE 4.1 (cont'd.) JANUARY 1986 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19	0.33						
20	0.81						
21	0.67						
22	0.99						
23	0.83						
24	0.90						
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE MARCH 1986

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13	0.35						
14	0.43						
15	0.53						

TABLE 4.1 (cont'd.) MARCH 1986 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16	0.45						
17	0.41						
18	0.51						
19	0.50						
20	0.44						
21	0.29						
22	0.72						
23							
24							
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1 (cont'd.) MAY 1986 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19							
20	1.05						
21							
22	0.52						
23	0.40						
24							
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE JULY 1986

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11	1.03						
12	0.91						
13	0.64						
14	0.95						
15	1.08						

TABLE 4.1 (cont'd.) JULY 1986 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16	0.70						
17	0.71						
18	1.15						
19	0.96						
20	0.65						
21	1.03						
22	0.76						
23	1.14						
24	0.67						
25	0.70						
26	0.37						
27	0.74						
28	0.40						
29	0.39						
30	0.86						
31	0.98						

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUST 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1	0.98						
2	1.0						
3	0.88						
4	0.49						
5	0.75						
6	1.89						
7	1.33						
8	0.90						
9	0.81						
10	0.84						
11	1.28						
12	0.93						
13	1.12						
14	0.78						
15	0.67						

TABLE 4.1 (cont'd.) AUGUST 1986 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16	1.12						
17	1.07						
18	0.75						
19	0.73						
20	0.70						
21	0.61						
22	0.65						
23	0.38						
24	0.99						
25	0.70						
26	0.81						
27	0.88						
28	0.83						
29	0.77						
30	0.62						
31	0.70						

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE SEPTEMBER 1986 (mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1	0.83						
2	0.40						
3	0.47						
4	1.04						
5	0.38						
6	0.51						
7	0.77						
8	0.68						
9	0.47						
10	0.93						
11	0.91						
12	0.62						
13	0.89						
14							
15							

TABLE 4.1 (cont'd.) MARCH 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29	1.36						
30							
31							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE APRIL 1985

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1	0.83						
2	0.99						
3	0.97						
4	0.99						
5	1.08						
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

TABLE 4.1 (cont'd.) MAY 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18	0.50						
19	1.09						
20	0.95						
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1 (cont'd.) JUNE 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18	0.65						
19	0.53						
20							
21							
22							
23							
24							
25							
26							
27	0.50						
28	0.66						
29							
30							
31							

TABLE 4.1 (cont'd.) JULY 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30	0.68						
31	0.69						

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUST 1985

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1	0.69						
2	0.60						
3	0.60						
4	0.50						
5	0.65						
6	0.57						
7	0.77						
8	0.82						
9	0.51						
10	0.55						
11	0.51						
12	0.61						
13	0.29						
14	0.72						
15	0.84						

TABLE 4.1 (cont'd.) AUGUST 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16	0.98						
17	1.07						
18	0.38						
19	0.97						
20	0.93						
21	0.61						
22	0.80						
23	0.51						
24	0.54						
25	0.63						
26	0.40						
27	0.60						
28	0.60						
29	0.63						
30	1.59						
31							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE SEPTEMBER 1985 (mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7							
8							
9	1.03						
10	0.55						
11	1.25						
12	0.74						
13							
14							
15							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE NOVEMBER 1985

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7	0.74						
8	1.23						
9	0.65						
10	0.68						
11	0.95						
12	1.08						
13	0.72						
14	0.56						
15	0.92						

TABLE 4.1 (cont'd.) NOVEMBER 1985 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18	0.51						
19	0.89						
20	0.79						
21	0.75						
22	0.68						
23	0.54						
24	0.60						
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1 (cont'd.) FEBRUARY 1984 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17	1.23						
18	1.23						
19	1.23						
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE APRIL 1984

(mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12	1.11						
13							
14							
15							

TABLE 4.1 (cont'd.) JULY 1984 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30	0.53						
31	0.99						

TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUST 1984 (mg/L)

MOE WPOS PROTOCOL

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
1	0.67						
2	1.10						
3	1.06						
4	1.17						
5	1.92						
6	0.96						
7	0.80						
8	1.02						
9	1.12						
10	1.22						
11	1.20						
12	1.83						
13	1.67						
14	1.51						
15	0.97						

TABLE 4.1 (cont'd.) AUGUST 1984 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16	1.30						
17	0.87						
18	0.92						
19	0.97						
20	1.32						
21	1.94						
22	1.18						
23	1.17						
24	1.17						
25	1.00						
26	0.88						
27	0.97						
28							
29							
30							
31							

TABLE 4.1 (cont'd.) DECEMBER 1984 (mg/L)

DATE	PAC	$KMnO_4$	LIME	SODA ASH	$NaHCO_3$	FLUORIDE	
						Dosage	Residual
16							
17							
18							
19							
20							
21							
22	1.09						
23	1.65						
24	0.68						
25	1.28						
26	1.97						
27	1.81						
28							
29							
30							
31							

TABLE 5

WATER PLANT OPTIMIZATION STUDY

"WATER QUALITY SUMMARY"

WPOS

TABLE 5.0: PLANT GRIMSBY WATER QUALITY - 1-YEAR SUMMARY

GENERAL CHEMISTRY			1 9 86												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
GENERAL CHEMISTRY																
ALKALINITY		R	101	101	99	99	103	100	99	95	95	96	102	101	0.2	
	mg/L	T	97	96	96	97	104	97	94	93	94	93	96	95.8	mg/L	
AMMONIUM	TOTAL	R													0.05	
	mg/L	T													mg/L	
CALCIUM		R													0.1	
	mg/L	T													mg/L	
CHLORIDE		R	24.6	42.0	30.8	25.7	16.0	27.5	27.0	25.5	23.5	24.0	30.5	26.5	0.2	250
	mg/L	T	24.8	35.6	36.6	27.6	30.6	30.0	30.5	29.5	26.5	27.5	28.0	29.5	mg/L	mg/L
COLOUR	ACU	R	45.0	26.5	5.0	1.5	1.7	3.5	2.0	3.0	2.5	2.5	6.0	9.5	0.5	5
		T	0.5	1.0	2.0	0.5	1.5	1.5	0.5	1.0	1.0	0.5	2.0	1.0	TCU	TCU
CONDUCTIVITY		R	325	397	354	329	361	334	333	313	313	326	374	337	0.01	
	umho/cm	T	340	372	374	332	374	336	338	323	316	331	339	341	UMHO/CM	
FIELD CHLORINE (COMBINED)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (FREE)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)		R													0.1	
	mg/L	T													mg/L	
FIELD PH		R													0.2	
		T														

TABLE 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		19 86 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	136	142	138	133	140	139	134	126	128	130	148	135	0.5	
mg/L	T	136	137	143	133	143	138	135	130	130	132	137	133.5	mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R													0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R													0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R													0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	8.1	8.1	8.2	8.4	8.3	8.2	8.2	8.3	8.3	8.3	8.3	8.2		
	T	7.1	7.5	7.9	8.3	8.3	8.2	8.2	8.1	8.3	8.3	8.0	8.0		
PHOSPHORUS FILTERED REACTIVE	R													0.01	
mg/L	T													mg/L	

TABLE 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		1 9 86 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
PHOSPHORUS TOTAL	R													0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R	14.1	18.8	12.0	13.1	4.75	2.25	3.16	4.39	4.37	5.58	8.83	23.3	0.01	1
NTU	T	0.26	0.18	0.21	0.53	0.30	0.15	0.13	0.11	0.10	0.14	0.14	0.56	FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 5.0: (cont'd.)

METALS (Cont'd)			19 86 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R		0.610	0.058				0.032	0.036	0.019		0.130	1.400	0.002	0.3
	mg/L	T		0.006	0.005	0.005	0.005		0.005	0.025	0.005		0.025	0.040	mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R													0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

TABLE 5.0: (cont'd.)

MASS SPEC. (Cont'd)		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		1 9 86													
TETRACHLORBUTANE ug/L	R T													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	R T													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	R	302	1056	213	118	2583	26	33	24	20	609	263	1169		
TOTAL COLIFORM BKGD count/100mL	R	1388	2183	647	48730	18010	4935	9415	66475	2266	1460	2603	5994		
FECAL COLIFORM MF count/100mL	R	6	6	7	3	84	2	12	10	7	7	5	27	0	0/0.1 mL
STANDARD PLATE COUNT MF count/100mL	R													0	500
TREATED WATER:															
PRESENT/ABSENT TEST (1)	AT PT							4	4	4 1	4	3	4		
TOTAL COLIFORM BACKGROUND MF count/100mL	T	1	0	0	0	800	0	0				1	0	0	OWDO Bactl
TOTAL COLIFORM MF count/100mL	T	0	0	0	0	0	0	0					0		

(1) Number of tests done per month.

TABLE 5.0: (cont'd.)

BACTERIA (Cont'd)		19 86												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T							0		0			0	0	ODWO Bactl
STANDARD PLATE COUNT MF count/1mL	T	6	4	2	4	380	600								
IF PRESENT/ABSENT TEST POSITIVE:															
Total Coliform 1-100/100mL	T									1		0			
FECAL COLIFORM P/A 1-10/100mL	T											0			
E. COLI 1-10/100mL	T									0					
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														
TOTAL COLIFORM BACKGROUND count/100mL	T									96					

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TABLE 5.0: PLANT GRIMSBY WATER QUALITY - 1-YEAR SUMMARY

GENERAL CHEMISTRY			19 85												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
GENERAL CHEMISTRY																
ALKALINITY		R	102.0	100.0	105.0	144.4	98.6	97.2	96.8	96.4	92.2		97.6	94.2	0.2	
	mg/L	T		84.0	82.0	73.0	90.0	88.0	90.0	90.0	83.0		82.0	81.0	mg/L	
AMMONIUM	TOTAL	R	0.027	0.015	0.112	0.035	0.041	0.059	0.110	0.069	0.036	0.036	0.019	0.010	0.05	
	mg/L	T													mg/L	
CALCIUM		R													0.1	
	mg/L	T													mg/L	
CHLORIDE		R	27.68	29.95	31.12	27.73	27.48	27.10	25.88	25.17	22.11	25.57	23.49	25.75	0.2	250
	mg/L	T		27.00	32.00	27.00	26.00	29.00	28.00	26.00	28.00		24.00	26.00	mg/L	mg/L
COLOUR	ACU	R	22.0	4.5	16.5	31.0	3.5	2.5	3.0	4.0	3.5		8.0	14.5	0.5	5
		T		0.5	1.0	1.5	1.0	0.5	0.5	1.5	1.0		0.5	0.5	TCU	TCU
CONDUCTIVITY		R	346	345	354	341	339	336	330	326	324	337	323	333	0.01	
	umho/cm	T		346	377	353	346	335	328	332	344		341	350	UMHO/CM	
FIELD CHLORINE (COMBINED)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (FREE)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)		R													0.1	
	mg/L	T													mg/L	
FIELD PH		R													0.2	
		T														

TABLE 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		19 85 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	139.4	135.0	139.0	137.3	132.0	127.0	123.0	127.0	130.0		130.0	130.0	0.5	
mg/L	T		136.0	139.0	133.0	133.0	129.0	126.0	128.0	130.0		136.0	136.0	mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R													0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R	.0110	.0076	.0218	.0227	.0055	.0100	.0084	.0094	.0105	.0086	.0132	.0062	0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R	0.308	0.252	0.532	0.440	0.310	0.320	0.360	0.318	0.336	0.275	0.435	0.228	0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	8.11	8.20	8.10	7.91	8.45	8.34	8.60	8.35	8.20		8.04	8.20		
	T		7.50	7.40	7.40	7.80	7.80	7.90	7.80	7.50		7.30	7.30		
PHOSPHORUS FILTERED REACTIVE	R	.0136	.0100	.0264	.0338	.0015	.0021	.0060	.0084	.0033	.0038	.0239	.0069	0.01	
mg/L	T													mg/L	

table 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		1985 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
PHOSPHORUS TOTAL mg/L	R													0.01 mg/L	
	T														
SODIUM mg/L	R													0.1 mg/L	
	T														
TOTAL SOLIDS mg/L	R													1 mg/L	
	T														
TURBIDITY NTU	R	22.7	18.8	33.9	23.9	2.3	1.69	1.78	6.21	5.97	4.35	35.8	8.1	0.01 FTU	1 FTU
	T	0.27	0.36	0.40	0.15	0.13	0.13	0.14	0.17	0.12	0.10	0.18	0.12		
METALS															
ALUMINUM mg/L	R													0.003 mg/L	
	T														
ARSENIC mg/L	R													0.001 mg/L	0.05 mg/L
	T														
BARIUM mg/L	R													0.001 mg/L	1 mg/L
	T														
BERYLLIUM mg/L	R													0.001 mg/L	
	T														
BORON mg/L	R													0.02 mg/L	5 mg/L
	T														
CADMIUM mg/L	R													0.0003 mg/L	0.005 mg/L
	T														

TABLE 5.0: (cont'd.)

METALS (Cont'd)			19 85 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	3.10	0.18	18.50	9.70	0.03	0.04	0.026	0.019	0.050		1.700	0.550	0.002	0.3
	mg/L	T		0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01		0.03	0.02	mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R													0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

TABLE 5.0: (cont'd.)

MASS SPEC. (Cont'd)		19 85 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
TETRACHLORBUTANE ug/L	R T													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	R T													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	R	358	573	454	734	9	5	8	92	6	313	3229	323		
TOTAL COLIFORM BKGD count/100mL	R	3250	2330	3025	3070	267	2451	80080	59600	49500	14720	32825	1953		
FECAL COLIFORM MF count/100mL	R	33	31	39	142	2	2	2	14	2	12	76	7	0	0/0.1 mL
STANDARD PLATE COUNT MF count/100mL	R													0	500
TREATED WATER:															
PRESENT/ABSENT TEST	AT PT														
TOTAL COLIFORM BACKGROUND MF count/100mL	T	0	0	0	0	0	0	321	0	0	0	1	0	0	OWDO Bact I
TOTAL COLIFORM MF count/100mL	T	0	0	0	0	0	0	0	0	0	0	0	1		

TABLE 5.0: (cont'd.)

BACTERIA (Cont'd)		1 9 85												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T												0	0	ODWO Bact I
STANDARD PLATE COUNT MF count/1 mL[1]	T	23	4	8	6	2	4	482	6	6	66	2	2		
IF PRESENT/ABSENT TEST POSITIVE:															
Total Coliform 1-4/100 mL	T														
FECAL COLIFORM P/A	T														
E. COLI P/A	T														
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														
TOTAL COLIFORM BACKGROUND count/100mL	T														

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TABLE 5.0: PLANT GRIMSBY WPOS WATER QUALITY - 1-YEAR SUMMARY

GENERAL CHEMISTRY			1984 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
GENERAL CHEMISTRY																
ALKALINITY		R	97	93	100	100	97	97	94	97	99	93	96	97	0.2	
	mg/L	T	90	86	86	83	81	88	83	90	79	80	87	85	mg/L	
AMMONIUM	TOTAL	R	0.008	0.111	0.047	0.032	0.046	0.064	0.062	0.056	0.048	0.034	0.015	0.025	0.05	
	mg/L	T													mg/L	
CALCIUM		R													0.1	
	mg/L	T													mg/L	
CHLORIDE		R	27.92	28.44	29.41	27.42	27.73	27.51	25.40	23.73	24.72	24.61	25.02	25.53	0.2	250
	mg/L	T	27.00	28.00	32.00	28.00	27.00	28.00	27.00	27.00	26.00	26.00	27.00	26.00	mg/L	mg/L
COLOUR	ACU	R	2.2	9.7	8.0	12.5	9.0	3.0	4.0	3.5	7.0	3.5	4.0	2.5	0.5	5
		T	3.0	0.1	1.0	0.5	0.5	1.5	1.0	1.5	0.05	1.5	0.5	1.0	TCU	TCU
CONDUCTIVITY		R	339	326	351	341	341	324	329	322	322	320	328	331	0.01	
	umho/cm	T	339	345	376	353	343	334	330	326	326	317	325	334	UMHO/CM	
FIELD CHLORINE (COMBINED)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (FREE)		R													0.1	
	mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)		R													0.1	
	mg/L	T													mg/L	
FIELD PH		R													0.2	
		T														

TABLE 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		19 84 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	138	128	142	147	133	129	132	135	125	121	130	127	0.5	
mg/L	T	137	127	142	146	135	135	136	135	132	125	129	126	mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R	0.387	0.538	0.462	0.478	0.414								0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R	.0048	.0310	.0060	.0152	.0075	.0109	.0061	.0108	.0110	.0055	.0042	.0028	0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R	0.27	0.75	0.32	0.34	0.34	0.32	0.32	0.37	0.35	0.28	0.24	0.23	0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	8.4	8.2	8.4	8.2	8.3	8.5	8.5	8.5	8.2	8.2	8.2	8.1		
	T	8.3	8.0	7.6	7.4	7.5	7.9	7.6	7.9	7.5	7.4	7.7	7.6		
PHOSPHORUS FILTERED REACTIVE	R	.0037	.0041	.0050	.0156	.0019	.0049	.0034	.0080	.0089	.0038	.0048	.0042	0.01	
mg/L	T													mg/L	

TABLE 5.0: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		1 9 84												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
PHOSPHORUS TOTAL	R													0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R	5.52	20.6	22.7	29.8	12.7	5.9	2.0	5.8	9.1	5.79	6.60	20.1	0.01	1
NTU	T	0.22	0.28	0.39	0.33	0.18	0.19	0.22	0.16	0.13	0.12	0.12	0.25	FTU	FTU
METALS															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 5.0: (cont'd.)

METALS (Cont'd)			1984 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	0.05	0.16	0.61	0.56	0.37	0.08	0.09	0.05	1.64	0.26	0.14	0.45	0.002	0.3
	mg/L	T	0.01	0.01	0.02	0.05	0.02		0.04	0.06	0.03	0.01	0.01	0.01	mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R													0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

TABLE 5.0: (cont'd.)

MASS SPEC. (Cont'd)		19 84 JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
TETRACHLORBUTANE ug/L	R T													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	R T													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	R	27	2220	348	72	188	8800	44	490	74	22	452	239		
TOTAL COLIFORM BKGD count/100mL	R	136	21030	2907	215	13280	125380	7720	115000	97650	3880	2615	1393		
FECAL COLIFORM MF count/100mL	R	7	1507	28	6	21	45	2	75	9	4	32	15	0	0/0.1 mL
STANDARD PLATE COUNT MF count/100mL	R	0												0	500
TREATED WATER:															
PRESENT/ABSENT TEST	AT PT														
TOTAL COLIFORM BACKGROUND MF count/100mL	T	0				1	45000	1	0	1	0	0	0	0	OWDO Bactl
TOTAL COLIFORM MF count/100mL	T	0				0	0	0	0	0	0	0	0		

TABLE 5.0: (cont'd.)

BACTERIA (Cont'd)		1 9 84												DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T													0	ODWO Bactl
STANDARD PLATE COUNT MF count/1mL	T	0	1	0	3	13	1580	98	436	64	5	3	4		
IF PRESENT/ABSENT TEST POSITIVE:															
Total Coliform 1-4/100 mL	T														
FECAL COLIFORM P/A	T														
E. COLI P/A	T														
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														
TOTAL COLIFORM BACKGROUND count/100mL	T														

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TABLE 5.0: (cont'd.) FOOTNOTES

1 = see individual footnotes for Agency of guideline origin

c = California State Department of Health Action Level

d = OWDO for DDT (contains other isomers such as OPDDT and PPDDT)

e = USEPA ambient guideline

ea = United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains other isomers)

ep = USEPA proposed maximum contaminant level for drinking water

g = suggested Health and Welfare Canada/Ontario Ministry of the Environment guideline value

h = World Health Organization (WHO) guideline

h* = World Health Organization (WHO) Odour Threshold

mg/L = milligrams per litre, parts per million, (ppm)

ng/L = nanograms per litre, parts per trillion, (ppt)

Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria

R = raw water

T = Treated Drinking Water

t = ODWO Interim maximum acceptable concentration, (IMAC)

ug/L = micrograms per litre, parts per billion, (ppb)

y = New York State (Taste and Odour) proposed drinking water guideline

++ = total Trihalomethanes

+++ = combined total: Heptachlor and Heptachlor Epoxide

* = if other than DWSP Detection Limit

** = total of Aldrin and Dieldrin

*** = Chlordane is a mixture of alpha and gamma isomers

I = Ministry of the Environment and Health and Welfare Canada, (IMAC)

TABLE 5.1: PLANT GRIMSBY WPOS WATER QUALITY - 3-YEAR SUMMARY

GENERAL CHEMISTRY		1986			1985			1984			19__			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
GENERAL CHEMISTRY															
ALKALINITY	R	103	95	99.2	144.4	92.2	102.2	100	93	96.7				0.2	
mg/L	T	104	93	94.6	90.0	73.0	84.3	90	79	84.8				mg/L	
AMMONIUM Total	R				0.112	0.010	0.047	0.111	0.008	0.046				0.05	
mg/L	T													mg/L	
CALCIUM	R													0.1	
mg/L	T													mg/L	
CHLORIDE	R	42.0	16.0	27.0	31.12	22.11	26.59	29.41	23.73	26.45				0.2	250
mg/L	T	36.6	24.8	29.7	32.00	24.00	27.3	32.00	26.00	27.4				mg/L	mg/L
COLOUR ACU	R	45.0	1.5	9.1	31.0	2.5	10.3	12.5	2.2	5.7				0.5	5
	T	2.0	0.5	1.1	1.5	0.5	0.8	3.0	0.05	1.0				TCU	TCU
CONDUCTIVITY	R	397	313	341	354	323	336	351	320	331				0.01	
umho/cm	T	374	316	343	377	328	345	376	317	337				UMHO/CM	
FIELD CHLORINE (COMBINED)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (FREE)	R													0.1	
mg/L	T													mg/L	
FIELD CHLORINE (TOTAL)	R													0.1	
mg/L	T													mg/L	
FIELD PH	R													0.2	
	T														

TABLE 5.1: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		1986			1985			1984			19__			OWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
FIELD TEMPERATURE	R														
°C	T														
FIELD TURBIDITY	R														1 FTU
FTU	T														
FLUORIDE	R													0.01	2.4
mg/L	T													mg/L	mg/L
HARDNESS	R	148	126	136	139	123	131.8	147	121	132				0.5	
mg/L	T	143	130	136	139	126	132.6	146	135	134				mg/L	
MAGNESIUM	R													0.05	
mg/L	T													mg/L	c
NITRATE	R							0.538	0.387	0.456				0.05	10 mg/L
mg/L	T													mg/L	as N
NITRITE	R				.0227	.0062	.0112	.0310	.0028	.0138				0.005	1 mg/L
mg/L	T													mg/L	as N
NITROGEN TOTAL KJELDAHL	R				0.532	.228	0.343	0.75	0.23	0.34				0.1	0.15
mg/L	T													mg/L	mg/L *
PH	R	8.4	8.1	8.2	8.60	7.91	8.23	8.5	8.2	8.3					
	T	8.3	7.1	8.0	7.90	7.30	7.57	8.3	7.4	7.7					
PHOSPHORUS FILTERED REACTIVE	R				.0338	.0015	.0116	.0156	.0019	.0057				0.01	
mg/L	T													mg/L	

TABLE 5.1: (cont'd.)

GENERAL CHEMISTRY (Cont'd)		19<u>86</u>			19<u>85</u>			19<u>84</u>			19__			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
PHOSPHORUS TOTAL	R				0.160	0.012	0.046	0.215	0.011	0.048				0.01	
mg/L	T													mg/L	
SODIUM	R													0.1	
mg/L	T													mg/L	
TOTAL SOLIDS	R													1	
mg/L	T													mg/L	
TURBIDITY	R	23.3	2.25	9.55	35.8	1.69	13.79	29.8	2.0	12.22				0.01	1
NTU	T	0.56	0.11	0.23	0.40	0.12	0.19	0.39	0.12	0.22				FTU	FTU
<u>METALS</u>															
ALUMINUM	R													0.003	
mg/L	T													mg/L	
ARSENIC	R													0.001	0.05
mg/L	T													mg/L	mg/L
BARIUM	R													0.001	1
mg/L	T													mg/L	mg/L
BERYLLIUM	R													0.001	
mg/L	T													mg/L	
BORON	R													0.02	5
mg/L	T													mg/L	mg/L
CADMIUM	R													0.0003	0.005
mg/L	T													mg/L	mg/L

TABLE 5.1: (cont'd.)

METALS (Cont'd)			1986			1985			1984			19__			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
			MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
CHROMIUM		R													0.001	0.05
	mg/L	T													mg/L	mg/L
COBALT		R													0.001	
	mg/L	T													mg/L	
COPPER		R													0.001	1
	mg/L	T													mg/L	mg/L
CYANIDE		R													0.001	0.2
	mg/L	T													mg/L	mg/L
IRON		R	1.400	0.019	0.326	18.50	0.03	3.08	1.64	0.05	0.37				0.002	0.3
	mg/L	T	0.040	0.005	0.013	0.040	0.010	0.016	0.060	0.010	0.025				mg/L	mg/L c
LEAD	mg/L	R													0.003	0.05
		T													mg/L	mg/L
MANGANESE		R													0.001	0.05
	mg/L	T													mg/L	mg/L
MOLYBDENUM		R													0.001	
	mg/L	T													mg/L	
MERCURY		R													0.01	1
	ug/L	T													ug/L	ug/L
NICKEL		R													0.002	
	mg/L	T													mg/L	

TABLE 5.1: (cont'd.)

MASS SPEC. (Cont'd)		1986			1985			1984			19__			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TETRACHLORBUTANE ug/L	R T													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	R T													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	R	2583	20	535	3229	5	509	8800	22	1080					
TOTAL COLIFORM BKGD count/100mL	R	66475	647	13676	80080	267	21090	125380	136	32600					
FECAL COLIFORM MF count/100mL	R	84	2	15	142	2	30	1507	2	146				0	0/0.1 mL
STANDARD PLATE COUNT MF count/ 1mL	R													0	500
TREATED WATER:															
PRESENT/ABSENT TEST	AT PT														
TOTAL COLIFORM BACKGROUND MF count/100mL	T	800	0	100	321	0	27	2	0	0				0	OWDO Bactl

TABLE 5.1: (cont'd.)

BACTERIA (Cont'd)		1986			1985			1984			19__			DWSP DETECTION LIMIT*	DRINKING WATER OBJ/ GUIDELINE[1]
		MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE	MAX	MIN	AVE		
TREATED WATER: (Cont'd)															
FECAL COLIFORM MF count/100mL	T				0	0	0							0	ODWO Bactl
STANDARD PLATE COUNT MF count/1mL	T				482	2	51	1580	0.0	184					
IF PRESENT/ABSENT TEST POSITIVE:															
Total Coliform 1-4/100 mL	T														
FECAL COLIFORM P/A	T														
E. COLI P/A	T														
AROMONAS P/A	T														
STAPH. AUREUS P/A	T														
TOTAL COLIFORM BACKGROUND count/100mL	T														

A0106A/eal

TABLE 5.1: (cont'd.) FOOTNOTES

1 = see individual footnotes for Agency of guideline origin
c = California State Department of Health Action Level
d = OWDO for DDT (contains other isomers such as OPDDT and PPDDT)
e = USEPA ambient guideline
ea = United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains other isomers)
ep = USEPA proposed maximum contaminant level for drinking water
g = suggested Health and Welfare Canada/Ontario Ministry of the Environment guideline value
h = World Health Organization (WHO) guideline
h* = World Health Organization (WHO) Odour Threshold
mg/L = milligrams per litre, parts per million, (ppm)
ng/L = nanograms per litre, parts per trillion, (ppt)
Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria
R = raw water
T = Treated Drinking Water
t = ODWO Interim maximum acceptable concentration, (IMAC)
ug/L = micrograms per litre, parts per billion, (ppb)
y = New York State (Taste and Odour) proposed drinking water guideline
++ = total Trihalomethanes
+++ = combined total: Heptachlor and Heptachlor Epoxide
* = if other than DWSP Detection Limit
** = total of Aldrin and Dieldrin
*** = Chlordane is a mixture of alpha and gamma isomers
1 = Ministry of the Environment and Health and Welfare Canada, (IMAC)

TABLE 6

WATER PLANT OPTIMIZATION STUDY

"MICROBIOLOGICAL QUALITY"

TABLE 6.0: MICROBIOLOGICAL QUALITY - RAW WATER (µg/L)

MOE WPOS PROTOCOL

		1985		1984	
		Chlor-a	Chlor-b	Chlor-a	Chlor-b
JAN	Max.	9.5	5.1	3.1	0.4
	Min.	0.8	0.3	1.6	0.2
	Avg.	4.0	1.8	2.3	0.3
	No. Tests	5	5	3	3
FEB	Max.	4.5	3.4	8.1	3.4
	Min.	2.7	1.6	3.0	0.4
	Avg.	3.4	2.4	5.6	1.5
	No. Tests	4	4	3	3
MAR	Max.	134.0	4.6	6.8	0.6
	Min.	2.9	2.4	1.3	0.1
	Avg.	36.3	3.2	4.6	0.4
	No. Tests	4	4	4	4
APR	Max.	19.5	25.9	9.4	1.7
	Min.	4.4	0.7	2.0	0.2
	Avg.	7.3	7.3	7.2	0.8
	No. Tests	4	4	5	5
MAY	Max.	4.4	1.1	13.0	0.8
	Min.	2.6	0.5	5.1	0.4
	Avg.	3.6	0.8	8.1	0.6
	No. Tests	5	5	5	5
JUN	Max.	3.8	0.8	14.1	3.0
	Min.	2.7	0.5	2.1	0.2
	Avg.	3.2	0.6	5.3	1.1
	No. Tests	4	4	4	4

TABLE 6.0 (cont'd.) (µg/L)

		1985		1984	
		Chlor-a	Chlor-b	Chlor-a	Chlor-b
JUL	Max.	6.8	1.2	5.6	1.7
	Min.	2.0	0.4	2.5	0.6
	Avg.	3.2	0.7	2.9	1.1
	No. Tests	5	5	4	4
AUG	Max.	2.8	0.9	3.1	1.5
	Min.	1.5	0.4	1.0	0.4
	Avg.	2.2	0.6	2.2	1.0
	No. Tests	4	4	4	4
SEP	Max.	5.4	1.6	5.4	4.2
	Min.	2.1	0.6	2.3	1.1
	Avg.	4.2	1.3	3.3	2.1
	No. Tests	5	5	4	4
OCT	Max.	5.2	0.8	2.6	1.0
	Min.	1.7	0.4	1.7	0.6
	Avg.	3.4	0.6	2.1	0.8
	No. Tests	4	4	3	3
NOV	Max.	3.3	0.6	6.6	4.9
	Min.	1.2	0.2	3.8	0.4
	Avg.	2.1	0.5	5.0	2.0
	No. Tests	3	3	3	3
DEC	Max.	2.8	0.5	10.5	1.0
	Min.	0.5	0.2	3.7	0.8
	Avg.	1.7	0.3	6.2	0.9
	No. Tests	5	5	3	3

TABLE 7

WATER PLANT OPTIMIZATION STUDY

"BACTERIOLOGICAL TESTING"

TABLE 7.0: BACTERIOLOGICAL TESTING 1986 (No. Of Analyses Per Category)

MOE WPOS PROTOCOL

		TOTAL COLI				FECAL COLI				FECAL STREP			
		A	B	C	D	A	E	F	G	A	H	I	J
JAN	R		2	2			4					4	
	T	4											
FEB	R			4			3	1			1	3	
	T	4											
MAR	R		2	2			3	1			2	2	
	T	4											
APR	R		4	1			5				4	1	
	T	5											
MAY	R		2		1		2	1			1	1	1
	T	3											
JUN	R		4				4						
	T	4											
JUL	R		5				2	2					
	T	5											
AUG	R		4				3	1					
	T	4											
SEP	R		5				5						
	T	5											
OCT	R		2	1			2	1					
	T	4											
NOV	R		3	1			3	1					
	T	4											
DEC	R		1	3			2	2					
	T												

NOTE: All results are for 100 mL samples; tests carried out at MOE lab, Resources Road.

A = Absent
B = 1-100
C = 101-5000
D = >5000

E = 0-10
F = 11-500
G = >500

H = 0-1
I = 2-50
J = >50

TABLE 7.0: BACTERIOLOGICAL TESTING 1985 (No. Of Analyses Per Category)

MOE WPOS PROTOCOL

		TOTAL COLI				FECAL COLI				FECAL STREP			
		A	B	C	D	A	E	F	G	A	H	I	J
JAN	R		2	2			2	2			2	1	1
	T	4											
FEB	R		2	2			2	2			1	2	1
	T	4											
MAR	R		1	2			2	1				2	1
	T	3											
APR	R		3	1			3		1		1	2	1
	T	4											
MAY	R		4				4				4		
	T	4											
JUN	R		3				3				3		
	T	4											
JUL	R		4				5				2	3	
	T	5											
AUG	R		3	1			1	3				4	
	T	4											
SEP	R		4				5				5		
	T	5											
OCT	R		3	2			4	1			1	3	
	T	4											
NOV	R			3	1			4				3	
	T	4											
DEC	R		1	4			4	1				2	
	T	3	2										

NOTE: All results are for 100 mL samples; tests carried out at MOE lab, Resources Road.

A = Absent
B = 1-100
C = 101-5000
D = >5000

E = 0-10
F = 11-500
G = >500

H = 0-1
I = 2-50
J = >50

TABLE 7.0: BACTERIOLOGICAL TESTING 1984 (No. Of Analyses Per Category)

MOE WPOS PROTOCOL

		TOTAL COLI				FECAL COLI				FECAL STREP			
		A	B	C	D	A	E	F	G	A	H	I	J
JAN	R		3				2	1				3	
	T	4											
FEB	R		1	2	1		2	1	1			3	1
	T												
MAR	R		3	1			2	2				4	
	T												
APR	R		3	1			4					4	
	T												
MAY	R		4	1			4	1			3	1	1
	T												
JUN	R		1	2	1		2	2			2	2	
	T												
JUL	R		5				5				5		
	T	3											
AUG	R		3	1			2	2			3		1
	T	3											
SEP	R		3	1			3	1			3	1	
	T	4											
OCT	R		5				5				3	2	
	T	5											
NOV	R		3	1			3	1			2	1	1
	T	4											
DEC	R		1	2			1	2			1	2	
	T	2											

NOTE: All results are for 100 mL samples; tests carried out at MOE lab, Resources Road.

A = Absent
B = 1-100
C = 101-5000
D = >5000

E = 0-10
F = 11-500
G = >500

H = 0-1
I = 2-50
J = >50

TABLE 7.1: BACTERIOLOGICAL TESTING (Count Per 100 mL)

MOE WPOS PROTOCOL

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JAN	R	6	302	33	358	7	27		
	T		0		0		0		
FEB	R	6	1056	31	573	1507	2220		
	T		0		0				
MAR	R	7	213	39	454	28	348		
	T		0		0				
APR	R	3	118	142	734	6	72		
	T		0		0				
MAY	R	84	2583	2	9	21	188		
	T		0		0				
JUN	R	2	26	2	5	45	8800		
	T		0		0				

TABLE 7.1:(cont'd.) (Count Per 100 mL)

		1986		1985		1984		1983	
		FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI	FECAL COLI	TOTAL COLI
JUL	R	12	33	2	8	2	44		
	T		0		0		0		
AUG	R	10	24	14	92	75	490		
	T		0		0		0		
SEP	R	7	20	2	6	9	74		
	T		0		0		0		
OCT	R	7	609	12	313	4	22		
	T		0		0		0		
NOV	R	5	263	76	3229	32	452		
	T		0		0		0		
DEC	R	27	1169	7	323	15	239		
	T		0		1		0		

APPENDIX D

TERMS OF REFERENCE

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more than one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/ iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

<u>Elements of Work</u>

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.